

THE EFFECT ON CARCASS EXCELLENCE OF PROPORTION OF ANIMAL PROTEIN IN THE HOG DIET¹E. W. CRAMPTON² AND G. C. ASHTON³*Macdonald College, Quebec*

[Received for publication July 29, 1946]

Most modern recommendations regarding the make-up of rations for swine emphasize the inclusion of protein of animal or marine origin. The minimum quantities specified seldom are less than 20% of the total protein. Experimental evidence supporting such an allowance is neither unanimous nor too convincing in the light of present knowledge of feeds and of swine requirements. Indeed it appears that what originally may have been recommended as desirable has in some instances later been interpreted as a necessity. Mitchell (1943) in his review of the need for animal protein in swine and poultry rations, points out that most of the instances where improved feeding value of rations has resulted from the inclusion of animal proteins can equally as well be explained on the grounds of minerals and vitamins as on the basis of amino acid supplementation.

With the severe shortage in Canada of feeds of animal or marine origin during the war years, the question of their minimum use was of special interest. Not only are matters of rate of growth and of feed efficiency of importance, but also the possible effect on the characteristics of their carcasses intended for bacon must be taken into account. Accordingly a feeding trial was conducted to obtain data relative to these questions.

METHODS OF INVESTIGATION

In order to establish the levels to which the proportion of animal protein, represented in this test by tankage, may be reduced from a "normal" of 20%, this feed was replaced by linseed oilmeal on a nitrogen equivalent basis so that 4 rations contained respectively, 20, 10, 5 and 0% of protein from animal origin. In addition a fifth group was included in which wheat germ was employed as a protein source.

Pure-bred Yorkshire pigs weaned at about 56 days of age, and started on test at initial weights of approximately 45 pounds, were used.

The basal feed for all pigs was No. 2 feed barley. This feed comprised from 81 to 85% of the ration of pigs up to 100 pounds in weight (see Table 1), but after that time the proportion was increased to approximately 90%. These proportions gave a protein content of the growing ration of 16% and of the fattening ration of 13%.

¹ Contribution from the Department of Nutrition, Faculty of Agriculture, Macdonald College, McGill University, Quebec. Journal Series Number 218.

² Professor of Nutrition.

³ Lecturer in Nutrition.

Three percent of a mineral mixture was included in all rations. It consisted of:—

28 lb. feeding bone meal
47 lb. ground limestone
25 lb. iodized salt
4 oz. ferric sulphate

Until they weighed 100 pounds, the pigs were fed three times daily in amounts limited only by appetite. From then on the pigs were fed twice a day. For feeding, the allowance of meal mixture was placed in feed troughs and about three times its weight of water poured over it. Until the pigs weighed 100 pounds, they received 15 cc. of cod-liver oil per day. Pigs were confined to individual feeding pens throughout the test.

RESULTS

EFFECT OF LEVEL OF ANIMAL PROTEIN

In Table 1 is a summary of the effects on pig gains, on feed efficiency and on carcass excellence of varying levels of animal protein in the ration.

TABLE 1.—SUMMARY OF EFFECTS ON PIG GAINS, FEED EFFICIENCY AND CARCASS EXCELLENCE OF VARYING LEVELS OF ANIMAL PROTEIN IN THE RATION

Ration Description	6 Tankage 6 Oilmeal 3 Minerals 85 Grain *** Animal Protein	3 Tankage 12 Oilmeal 3 Minerals 82 Grain *** Animal Protein	1.5 Tankage 14 Oilmeal 3 Minerals 81.5 Grain *** Animal Protein	0 Tankage 16 Oilmeal 3 Minerals 81 Grain *** Animal Protein	0 Tankage 8 Oilmeal 10 Wheat germ 3 Minerals 79 Barley *** Animal Protein
	20%	10%	5%	0%	0%
No. pigs	24	24	24	24	24
Initial wt., lb.	45.4	45.3	44.3	45.6	45.6
Feed eaten, lb.	650	639	636	646	596
Days fed	108	111	110	110	101
Daily gain, lb.	1.46	1.38	1.40	1.40	1.54
Daily feed, lb.	6.0	5.8	5.8	5.9	5.9
Adjusted gain, lb.	1.42	1.40	1.42	1.40	1.54
Carcass data—					
Length of side, in.	30.0	30.0	30.1	29.9	30.2
Depth of neck fat, in.	1.78	1.75	1.72	1.76	1.75
Lean in rasher, %	42.0	41.7	40.7	40.9	42.3
Area pork chop, sq. in.	4.9	5.0	4.9	4.8	5.2
Score	74	76	78	75	82
% carcasses—Grade A	46	67	46	50	50
Grade B	50	33	50	50	50

Before commenting in detail on the data of this table, it may be well to point out that the averages of gains and of feed consumption include pigs which were restricted in feed with the intention of reducing their daily gain. This does not affect the comparisons between the protein levels since there were in each lot equal numbers of pigs restricted as compared to those on full feed. It does, however, tend to reduce the average gains of the test. It may be stated that the average daily gain, over the entire feeding period, of the pigs full-fed throughout was 1.52 pounds per day, while the gain for those that were restricted during the fattening period, averaged 1.35 pounds.

One of the first things to be noted in this test is that the reduction of the animal protein, from 20% to 0%, has not appreciably affected the rate of gain of the pigs, nor has it affected feed consumption, or feed efficiency. Statistically, the difference between 1.46 pounds per day gain on the 20% animal protein and 1.38 pounds per day gain on the 10% animal protein is just on the level of significance with odds at the 5% point. However, the daily gains of the 5% and 0% animal protein groups were not statistically below that of the lot fed 20% protein.

It will also be noted that the reduction of the animal protein proportions has not affected the length of the pig as measured by length of side of the carcass; nor has it affected significantly, the depth of fat or the percentage of lean in the carcass.

In connection with the carcass grade, the group receiving 10% of animal protein has shown a larger proportion of grade A carcasses than in any of the other 3 lots, and it is obvious, therefore, that this cannot be the effect of animal protein. In fact, ration differences have not affected average carcass grade or score in this test.

The inclusion of wheat germ as a substitute for the tankage has actually resulted in increased rate of gain at no increase in feed intake. Nor was there any evidence of a fatter carcass than was produced on the animal protein lots.

These findings are not in accordance with the view commonly held of the desirability of the inclusion of some protein of animal origin in the bacon hog ration. From the standpoint of rate of gain, the wheat germ meal, as a supplement to oilmeal, gave a response significantly greater than did tankage. This might be interpreted as a protein supplementary effect with oilmeal greater than that of tankage. The question of course may be raised as to whether or not "wartime" tankage is the equal of pre-war meat meal. The fact remains, however, that in this test the pigs receiving a wheat germ-oilmeal protein supplement made more rapid and more efficient gains than others on either oilmeal plus tankage or on oilmeal as the protein supplement.

CONCLUSION

Data from this test involving 120 pigs fails to indicate that present tankage up to 20% of the total protein enhances the nutritive value of the bacon hog ration carrying 15% crude protein in which oilmeal or oilmeal plus wheat germ comprise the only other source of protein excepting that of the basal feed, barley.

REFERENCES

1. MITCHELL, H. H. Is Animal Protein An Essential Constituent of Swine and Poultry Rations? National Research Council (U.S.) Reprint and Circular Series. No. 117. May, 1943.

A METHOD OF ESTABLISHING RUST EPIDEMICS IN EXPERIMENTAL PLOTS¹

W. J. CHEREWICK²

Dominion Laboratory of Plant Pathology, Winnipeg, Manitoba

[Received for publication August 14, 1946]

In any cereal or other crop-improvement programme where disease resistance is considered, it is essential that the plant populations under investigation be subjected to epidemics of diseases, particularly the various rusts, to facilitate the selection of resistant plants as well as to study the inheritance of disease resistance. Rust epidemics do not occur naturally every year with the same intensity and, even under conditions of a severe epidemic, only a few of the known physiologic races may be present in any one district. In order to select plants resistant to any given rust it is desirable to use all the races that may occur in those regions where the new variety may be grown. A method, therefore of inducing rust epidemics artificially is of great importance.

REVIEW OF PREVIOUS METHODS

As early as 1920 Durrell and Parker (1) described a method of increasing rust inoculum in the greenhouse and inoculating experimental plots in the field. They found that, in the greenhouse, "young plants would produce spores for a week or 10 days, while older plants would bear spores for a month in great profusion". They used older plants, therefore, to increase the inoculum for field inoculations. They tested several methods of field inoculation, including spraying a spore suspension on plants with a knapsack sprayer and dusting dry spores on plants thoroughly moistened with a fine mist from a sprayer. The latter method, they found, gave the best results when rust spores were applied in "large quantities at intervals of 1 or 2 days during that part of the growing period when the plants were making rapid vegetative growth".

The method developed by Durrell and Parker (1) appears to have been overlooked or not adopted by subsequent investigators. At least, no further reference to the method has been noted. It also remained unknown to the author until after a similar method had been developed at Winnipeg.

In 1924, Stakman and Aamodt (3) described a method of establishing an epidemic of wheat stem rust in Minnesota. They infected with stem rust common barberry bushes growing adjacent to the wheat plots. They also sprayed the border rows, after sunset or on wet cloudy days, with a suspension of rust spores and kept the sprayed plants under bell jars for 40 hours. In addition, they placed between the rows of their plots wheat seedlings grown in pots in the greenhouse and heavily infected with stem rust. Mackie (2), in California, apparently not succeeding with similar methods, used late sown wheat to initiate infection and then irrigated his plots to induce the development of rust and some other cereal diseases. In Kenya, Thorold (4) described a method somewhat similar to that of Stakman and Aamodt (3). He planted his so-called "surround" rows at

¹ Contribution No. 880 from the Division of Botany and Plant Pathology, Science Service, Dominion Department of Agriculture, Ottawa, Canada.

² Assistant Plant Pathologist, Dominion Laboratory of Plant Pathology, Winnipeg, Man.

least 10 days earlier than the experimental plots and made his first inoculations on plants in the seedling stage, the rust spores being spread over the leaves with a flattened needle and the plants then covered with bell jars for 60 hours. Zehner and Humphrey (5) introduced the method of injecting spores into cereal plants with a hypodermic needle. This method gave good infections regardless of the air humidity and, consequently, there was no need for the bell jars or any other humid chambers. It was, however, a slow and tedious method, requiring many days to inoculate border rows totalling several miles in length.

With the increase in area devoted to the growing of hybrid material and to various rust experiments, improvements in the method of establishing rust epidemics became desirable and, accordingly, various tests were made at Winnipeg during the last 10 years to devise a simpler and more efficient method. This method is described in the following paragraphs.

THE IMPROVED METHOD

PRODUCTION OF RUST INOCULUM IN THE GREENHOUSE

In the laboratory, where physiologic specialization of cereal rusts is being studied, small amounts of rust spores of different races are collected from the differential hosts and stored separately in glass vials in a refrigerator. It has been found that dry spores stored at a temperature of from 0° to 3° C. will remain viable for as long as 12 months. For the production of rust spores for field inoculum, plants of a susceptible host are grown in well fertilized soil in 6-inch pots with 3 plants per pot. When in the shot-blade stage, the plants are inoculated by means of a small duster (Fig. 1) with urediospores diluted with talc, or any other finely-ground inert material, at the rate of 1 part of spores to 10 parts of talc. Inoculation may be made with spores of a single physiologic race or a mixture of races. After inoculation the plants are sprayed with a fine mist of water and left in a moist chamber for 24 hours. An inexpensive and convenient moist chamber can be made by covering a frame built of 1 x 2 inch lumber with heavy cotton sheeting or cardboard. As soon as the inoculated plants have been

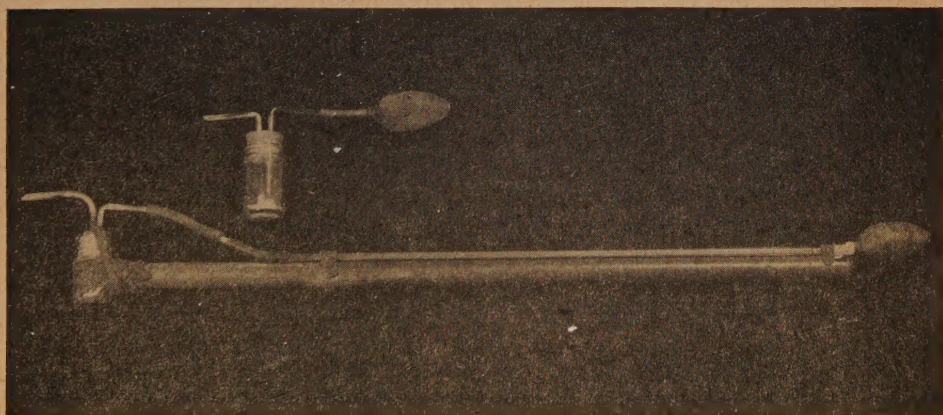


FIGURE 1—Top—A small duster used for rust inoculation in the greenhouse.
Bottom—Similar duster with a 30-inch handle for field inoculations.

placed in the chamber, the inside and outside of the latter is thoroughly wetted. The temperature of the greenhouse is then allowed to drop to 10° to 15° C. Under these conditions a very heavy infection is obtained. The drop in temperature is necessary to ensure condensation of moisture on the plants, and the lower temperature (about 15° C.) is favourable for the germination of the urediospores.

After the inoculated plants are removed from the moist chamber, they are kept in a moderately cool greenhouse and as soon as they start heading the spikes are cut off to prevent breakage of the plants and also to lengthen the life of the infected leaves. When rust infections develop the spores are collected every 2 or 3 days by inclining the infected plants over a smooth sheet of paper and then tapping lightly on the stems with a short stick to shake off the mature spores. A hundred pots of well grown plants kept under favourable conditions will yield over 400 cc. of rust spores.

FIELD INOCULATION

Prior to the development of the present method, field inoculations at Winnipeg were made partly by transplanting plants heavily infected with a particular rust in the greenhouse, but mainly by the injection method developed by Zehner and Humphrey (5). The injections were usually started when the plants were in the third or fourth leaf stage, several plants being inoculated in every few yards of the row. This method always resulted in good infection at the point of inoculation, but only the leaf that was in the sheath at the time of injection, or a part of it, became infected. These infection centres, under favourable conditions, were sufficient to spread the rust throughout the border rows and the plots, but under conditions that were not conducive to a rapid spread of rust the injections might have to be repeated 2 or 3 times. Considering that, at Winnipeg, the total length of the border rows to be inoculated usually exceeds 10 miles, the establishment of rust epidemics by this method required a great deal of work.

In Nature rust spores either settle down from the air or are carried down by rain showers and, when a spore shower is followed by dews or muggy weather, a heavy rust infection results. Accordingly, the dusting of rust spores over the border rows was tested in comparison with the following alternative methods: (*a*) spraying a spore suspension on the plants with a knapsack sprayer, (*b*) transplanting plants heavily infected in the greenhouse, and (*c*) injecting plants with a spore suspension by means of a hypodermic needle. Several tests with all 4 methods were made and in each instance dusting dry spores gave the best results. Naturally, when an application of rust spores was followed by hot, dry, and windy weather for several days, very little or no infection developed, but if applied on a calm evening after sunset when plants were becoming damp from the formation of dew, very heavy infection resulted.

The first year the method of dusting dry spores was used, it was found that a large quantity of spores was required to inoculate all the border rows. A modification of the method was suggested as a result of tests made by Brown¹ on the effect of diluting rust spores with talc. He found

¹ Unpublished data by A. M. Brown, Dominion Laboratory of Plant Pathology, Winnipeg, Man.

that a mixture of 1 part of spores to 10 parts of talc by volume gave as good infection as the spores alone. Observations made subsequently on plants dusted with this mixture revealed that the talc particles acted as nuclei for the condensation of water vapour from the air. The leaves of a plant dusted with talc powder became covered with minute droplets of water over the entire surface while undusted leaves had much larger droplets mainly on their edges. Talc, therefore, acts not only as a diluent of spores but, by virtue of its moisture adsorbing capacity, it enables a higher percentage of the spores to germinate and penetrate into the tissues of the inoculated plants.

The improved method, consisting of dusting rust spores mixed with talc at the rate of 1 : 10 over the border rows on a clear calm evening after sunset, has now been used at this laboratory for several years with very good results. The inoculum is applied with a small duster (Fig. 1) suspended on a piece of broom handle about 2 feet long so that plants in the border row in their third or fourth leaf stage can be dusted without bending down. One person can inoculate about 3 miles of border rows in an hour, depending on the speed at which he walks. With thick and leafy border rows, one dusting results in a sufficiently heavy infection to ensure a good epidemic.

SUMMARY

A simple and reliable method of establishing rust epidemics in experimental plots is described. The method consists in dusting the border rows with dry urediospores diluted with talc in the proportion of 1 part of spores to 10 parts of talc. The spores are produced in the greenhouse on large well-developed plants growing in 6-inch pots with 3 to 4 plants per pot. Every 2 or 3 days the spores are collected by shaking heavily infected plants over a smooth sheet of paper. The heaviest infection was obtained in the field when inoculations were made on clear calm evenings as the dew was beginning to form.

REFERENCES

1. DURRELL, L. W. and J. H. PARKER. Comparative resistance of varieties of oats to crown and stem rusts. Iowa Agr. Exp. Sta. Research Bull. 62 : 27-56d. 1920.
2. MACKIE, W. W. A field method of insuring positive attack with some cereal diseases. Phytopathology, 18 : 617-621. 1928.
3. STAKMAN, E. C. and O. S. AAMODT. The effect of fertilizers on the development of stem rust of wheat. Jour. Agr. Research, 27 : 341-379. 1924.
4. THOROLD, C. A. Production of an artificial epidemic of wheat stem rust in Kenya Colony. Ann. Appl. Biology, 21 : 614-620. 1934.
5. ZEHNER, M. G. and H. B. HUMPHREY. Smuts and rusts produced in cereals by hypodermic injection of inoculum. Jour. Agr. Research, 38 : 623-627. 1929.

DIGESTIBILITY STUDIES WITH SWINE

II. THE DIGESTIBILITY OF GRAINS AND VEGETABLE PROTEIN CONCENTRATES AT DIFFERENT STAGES OF THE GROWING AND FATTENING PERIOD¹

C. J. WATSON², J. W. KENNEDY³, W. M. DAVIDSON³, C. H. ROBINSON⁴, and G. W. MUIR⁵

Dominion Department of Agriculture, Ottawa, Canada

[Received for publication August 12, 1946]

In the first paper of this series (3) the coefficients of digestibility of the nutrients of a number of grains and concentrates were determined with swine at various periods between 40 kilograms and 150 kilograms in weight. It was found that the digestibility was not affected by the stage of growth. Crampton and Whiting (1) determined the coefficients of digestibility of feed barley, screenings and feed oats at different stages of the growing period. They used a lower initial weight, namely about 25 kilograms and a lower final weight, namely about 90 kilograms. No differences in the digestibility due to the age or size of the pig were observed.

In the present paper the studies on digestibility are continued with buckwheat, rye, screenings, barley and vegetable protein concentrates from different sources. Barley was used as a basal ration with the vegetable protein concentrates. The following 8 feeds were used.

- (1) Soybean Oil Meal—Expeller process, Central Soya Co. Reg'd No. 1328.
- (2) Soybean Oil Meal—Solvent process, Archer Daniels, Montreal. Reg'd No. 5409.
- (3) Linseed Oil Cake Meal—Carpenter's, Hamilton. Reg'd No. 4185.
- (4) Linseed Oil Cake Meal—Sherwin-Williams Co., Montreal, Screw Press method. Reg'd No. 3335.
- (5) Buckwheat—No. 1 C.E., Silverhull Variety.
- (6) Rye—No. 3 C.W. Feed Rye.
- (7) Screenings—Ground No. 2 Feed.
- (8) Barley—No. 1 Feed Western.

For the digestion trials 8 pure bred Yorkshire barrows were used. They were about 60 kilograms in weight at the beginning of the experiment and about 150 kilograms at the conclusion. The 8 rations were fed to the 8 pigs in 8 periods in a randomized Latin square set-up. The animals and periods were numbered respectively 9 to 16. Each period was 24 days long consisting first of a 4-day pre-experimental subperiod in which the animals were allowed exercise and a standard pig ration. This was followed by a changeover subperiod of 6 days, a preliminary subperiod of 7 days and a collection subperiod of 7 days. The concentrates were fed with barley in the ratio of 1 to 2. The remaining feeds were fed alone. Supplements of salt, vitamin A and vitamin D were given. Rations were fed in the form of a slop.

¹ Contribution No. 124, Division of Chemistry, Science Service, Dominion Department of Agriculture, Ottawa, Canada.

² Chemist, Division of Chemistry, Science Service, Dominion Department of Agriculture, Ottawa, Canada.

³ Assistants in Chemistry, Division of Chemistry, Science Service, Dominion Department of Agriculture, Ottawa, Canada.

⁴ Dominion Agricultural Chemist, Division of Chemistry, Science Service, Dominion Department of Agriculture, Ottawa, Canada.

⁵ Dominion Animal Husbandman, Division of Animal Husbandry, Experimental Farms Service, Ottawa, Canada.

PROGRESS OF EXPERIMENT

In the 8 periods there was one feed refusal, namely Animal 10 receiving rye in Period 10. The results of this individual trial were discarded. The remaining pigs of that period and all the pigs in the remaining periods maintained satisfactory health and appetite.

RESULTS

Summaries of the data pertinent to the discussion are given in Tables 1 and 2. Further data are given in Tables 3 to 7 inclusive. Table 3 presents the mean composition of the feeds. Table 4 gives the mean coefficients of digestibility for the individual feeds. Table 5 gives the daily rations; Table 6, the individual coefficients of digestibility for each nutrient for each feed; Table 7, the individual coefficients of digestibility for the vegetable protein concentrates calculated from the mixed rations with barley. In the statistical examination of the data, the method of Yates (4) was used to estimate the missing value for rye in Period 10, in order to apply tests of significance. Detailed analyses of variance are not presented but necessary differences are included in the tables.

DISCUSSION

Table 1 gives the mean coefficients of digestibility for each nutrient, firstly for each period and secondly for each animal. Beneath the individual columns are given the total range from the lowest to the highest values and the necessary differences between any two means. It will be noted that there was little effect of either period or animal. For instance, in the case of the dry matter, the total range with either animal or period was 1.6 absolute per cent. Between any of the Periods 11 to 16 there were no statistical differences. Period 10 was slightly higher than the rest. Period 9 was slightly higher than Period 14. In the case of the animals, No. 10 was slightly lower than the rest and No. 14 slightly higher. Otherwise, there were no significant differences. The same conditions were true generally for the organic matter, nitrogen, crude fibre and nitrogen free extract. The ether extract showed more variation than the other nutrients.

These results confirm those found previously that the digestibility of feeds determined with swine is not affected by the stage of growth.

Table 2 compares the various feeds on the basis of their contents of total digestible nutrients and digestible protein. These are expressed as percentages of the dry matter. Details concerning the chemical composition and the coefficients of digestibility of the individual nutrients will be found in Tables 3, 4, 6 and 7. The values for the vegetable protein concentrates were calculated from the mixed rations with barley. One fact should be noted in connection with the calculation of the total digestible nutrients in the soybean oil meal by the solvent process. The ether extract was only approximately one-half of one per cent and the coefficients of digestibility of this nutrient when calculated from the rations with barley gave negative results. This was taken into account in calculating the total digestible nutrients.

On the basis of the content of total digestible nutrients, it will be seen from Table 2 that the soybean oil meal produced by the expeller process and the rye were the highest of all feeds and, themselves, approximately

TABLE 1.—MEAN COEFFICIENTS OF DIGESTIBILITY OF NUTRIENTS OF RATIONS AS FED
ARRANGED BY ANIMAL MEANS AND PERIOD MEANS (EACH MEAN BASED ON 8 VALUES,
MISSING VALUE INCLUDED IN MEANS OF PERIOD 10 AND ANIMAL 10)

Designation	Mean coefficients of digestibility in % of Nutrients					
	Dry Matter	Organic Matter	Nitrogen	Ether Extract	Crude Fibre	N-Free Extract
Period 9	81.7	83.2	82.2	70.5	28.1	88.8
10	82.4	83.7	84.0	63.7	31.0	89.0
11	81.3	82.8	83.8	73.9	28.2	88.2
12	81.2	82.5	83.4	68.2	30.6	87.6
13	81.0	82.4	84.1	66.7	30.8	87.5
14	80.8	82.2	82.9	66.3	29.2	87.6
15	81.5	82.9	82.8	65.6	30.6	88.2
16	81.1	82.6	82.2	76.0	31.6	87.8
Total range	1.6	1.5	1.9	12.3	3.5	1.5
Necessary Difference*	0.9	0.8	1.4	5.6	3.4	0.8
Animal 9	81.6	83.0	84.6	69.3	29.6	88.2
10	81.2	82.7	82.0	65.5	24.9	88.4
11	81.3	82.8	83.7	66.2	29.2	88.0
12	81.0	82.4	82.6	68.0	31.6	87.6
13	81.2	82.5	83.6	71.0	31.5	87.8
14	82.5	83.8	84.3	71.7	32.2	88.9
15	81.2	82.6	82.5	67.8	33.5	87.9
16	80.9	82.5	82.1	71.1	27.8	88.0
Total range	1.6	1.4	2.6	6.2	8.6	1.3
Necessary Difference*	0.9	0.8	1.4	5.6	3.4	0.8

* At P of 0.05.

TABLE 2.—MEAN VALUES FOR THE TOTAL DIGESTIBLE NUTRIENTS AND THE
DIGESTIBLE PROTEIN IN THE DRY MATTER OF THE INDIVIDUAL FEEDS
(Mean of 7 values for rye and 8 for the remainder)

Feedstuff	Digestible Nutrients in % of Dry Matter	
	Total	Protein*
<i>Soybean Oil Meal</i>		
(a) Expeller	88.8	38.4
(b) Solvent	81.7	40.6
<i>Linseed Oil Meal</i>		
(a) Carpenter	81.0	29.0
(b) Sherwin-Williams	81.3	26.9
Rye	88.7	11.8
Buckwheat	75.7	10.0
Screenings	79.3	13.7
Barley	83.9	10.8
Necessary Difference**	2.0	0.8

* Protein factors used (2) were, soybean oil meal—5.71, linseed oil meal—5.30, rye—5.83, buckwheat—5.83, screenings—6.25, and barley—5.83.

** At P of 0.05.

equal. They were higher than the barley. The two linseed oil meals and the soybean oil meal prepared by the solvent process had approximately equal contents of total digestible nutrients. They were slightly lower than the barley. Buckwheat had the lowest content. The screenings were less than the linseed oil meals but not quite significantly so.

TABLE 3.—MEAN CHEMICAL COMPOSITION OF FEED STUFFS
(Means of 8 values)

Feedstuff	Dry Matter %	Chemical Composition of Dry Matter in %				
		Ash	Protein*	Ether Extract	Crude Fibre	N-Free Extract
<i>Soybean Oil Meal</i>						
(a) Expeller	90.40	5.85	44.20	5.89	6.26	37.81
(b) Solvent	90.22	6.30	45.12	0.59	6.05	41.93
<i>Linseed Oil Meal</i>						
(a) Carpenter	91.08	5.07	35.25	6.48	9.11	44.10
(b) Sherwin-Williams	90.69	5.72	32.86	7.58	9.15	44.68
Rye	87.41	2.02	13.88	1.81	2.76	79.52
Screenings	88.69	2.66	16.77	4.76	7.31	68.49
Buckwheat	87.03	2.46	13.03	2.64	12.05	69.82
Barley	87.93	2.72	12.89	2.07	5.77	76.55

* Protein factors—see Table 2.

TABLE 4.—MEAN COEFFICIENTS OF DIGESTIBILITY OF INDIVIDUAL FEEDS
(Mean of 7 values for rye and 8 for the remainder)

Feedstuff	Mean Coefficients of Digestibility of Nutrients in %					
	Dry Matter	Organic Matter	Nitrogen	Ether Extract	Crude Fibre	N-Free Extract
<i>Soybean Oil Meal</i>						
(a) Expeller	86.7	88.1	86.8	83.3	79.0	91.1
(b) Solvent	87.4	88.9	90.0	161.8	77.3	91.9
<i>Linseed Oil Meal</i>						
(a) Carpenter	74.9	77.4	82.3	88.2	42.1	80.0
(b) Sherwin-Williams	74.2	76.7	81.9	91.0	37.7	79.2
Rye	88.9	89.8	84.7	39.9	41.2	93.3
Screenings	75.4	76.7	81.8	82.7	20.7	80.7
Buckwheat	74.1	75.1	76.9	82.4	6.8	85.9
Barley	83.1	84.6	83.5	66.8	24.0	89.7
Necessary Difference*	2.0	1.9	2.0	**	9.5	2.1

* At P of 0.05.

** Error too great to give a valid value.

As far as the digestible protein was concerned the two soybean oil meals had the highest content. This was due both to a higher digestibility and a higher absolute content of protein. The soybean oil meal by the solvent process was slightly higher than that by the expeller process. This was due mainly to a higher digestibility. Both linseed oil meals contained over 25% of digestible protein. One was slightly higher than the other. This was due to a difference in the absolute amount of protein and not to any difference in digestibility. Of the grains, screenings had the highest digestible protein content followed by the rye, barley and buckwheat in descending order.

TABLE 5.—DAILY FEED CONSUMPTION
(Weights in kilograms, ration legend given at foot of table)

Period No.	Feed consumed by animals numbered							
	9	10	11	12	13	14	15	16
9	B 1.00 SI 0.5	Bu 1.8	B 1.0 LI 0.5	B 1.8	B 1.2 LII 0.6	S 1.6	R 1.6	B 1.2 SII 0.6
10	B 1.35 LII 0.65		B 2.0	B 1.35 LI 0.65	B 1.35 SI 0.65	Bu 2.00	B 1.35 SII 0.65	S 2.00
11	Bu 2.20	B 1.35 LII 0.65	S 1.60	R 2.40	B 1.35 SII 0.65	B 2.20	B 1.60 SI 0.80	B 1.60 LI 0.80
12	B 1.30 SII 0.65	B 1.80	R 2.00	B 1.30 SI 0.65	Bu 1.8	B 1.30 LI 0.65	S 2.00	B 1.30 LII 0.65
13	B 1.50 LI 0.75	B 1.75 SII 0.85	B 1.75 LII 0.85	S 2.50	R 2.50	B 1.75 SI 0.85	Bu 2.50	B 2.00
14	B 2.60	B 1.80 SI 0.90	Bu 2.60	B 1.80 LII 0.90	S 2.60	B 1.80 SII 0.90	B 1.80 LI 0.90	R 2.60
15	R 2.20	S 2.00	B 1.80 SII 0.90	Bu 3.00	B 1.80 LI 0.90	B 1.80 LII 0.90	B 2.70	B 2.00 SI 1.00
16	S 2.20	B 1.80 LI 0.90	B 1.80 SI 0.90	B 1.80 SII 0.90	B 2.70	R 2.40	B 1.80 LII 0.90	Bu 2.80

Ration legend

- SI —Soybean Oil Meal—Expeller process, Central Soya Co.
 SII—Soybean Oil Meal—Solvent process, Archer Daniels, Montreal.
 LI —Linseed Oil Cake Meal—Carpenter's, Hamilton.
 LII—Linseed Oil Cake Meal—Sherwin-Williams Co., Montreal, Screw Press method.
 Bu —Buckwheat—No. 1 C. E., Silverhull Variety.
 R —Rye—No. 3 C. W. Feed Rye.
 S —Screenings—Ground No. 2 Feed.
 B —Barley—No. 1 Feed Western.

TABLE 6.—COEFFICIENTS OF DIGESTIBILITY OF RATIONS IN TABLE 5

Nutrient	Period No.	Coefficients of digestibility in % of following rations							
		Barley	Rye	Buck-wheat	Screen-ings	Mixed ration with barley			
						Linseed Oil Meal		Soybean Oil Meal	
						No. 1	No. 2	No. 1	No. 2
Dry Matter	9	82.9	89.3	73.6	78.2	81.0	79.6	86.5	82.8
	10	83.7	—	76.1	77.7	81.0	80.3	85.2	85.0
	11	83.7	89.0	74.4	75.0	78.9	80.2	84.2	85.2
	12	82.6	88.6	74.5	75.2	80.2	80.1	82.9	85.1
	13	82.6	88.6	73.7	74.0	80.9	79.9	84.4	84.0
	14	82.6	88.6	74.1	72.7	80.2	79.5	82.8	85.8
	15	82.6	88.8	74.2	76.3	80.0	81.7	84.4	84.1
	16	83.8	89.7	72.3	74.4	80.5	79.5	84.0	84.3
Organic Matter	9	84.4	90.0	74.7	79.6	82.8	81.4	87.8	84.6
	10	85.2	—	76.9	78.9	82.7	82.2	86.5	86.4
	11	85.2	89.8	75.3	76.5	81.1	82.2	85.6	86.5
	12	84.1	89.5	75.3	76.3	81.9	81.9	84.4	86.4
	13	84.2	89.4	74.6	75.2	82.7	81.9	85.8	85.5
	14	84.1	89.6	75.0	73.9	81.9	81.3	84.3	87.1
	15	84.3	89.6	75.2	77.3	81.8	83.5	86.0	85.7
	16	85.3	90.7	73.6	75.7	82.5	81.5	85.6	85.9
Nitrogen	9	80.9	81.9	75.1	81.2	82.8	83.5	89.0	83.3
	10	84.8	—	79.4	83.1	84.4	83.1	85.2	87.9
	11	84.4	85.5	76.7	83.9	81.0	82.4	85.1	91.0
	12	82.1	84.7	79.0	81.5	83.0	82.3	84.9	89.7
	13	85.0	84.5	78.2	82.1	86.0	83.6	86.7	86.8
	14	84.9	84.1	77.5	80.2	82.4	81.0	83.4	89.8
	15	81.9	86.0	76.2	80.7	81.7	84.0	85.1	86.7
	16	83.6	85.9	73.2	81.4	80.9	80.8	85.8	86.1
Ether Extract	9	65.9	40.0	82.0	84.4	80.7	81.9	84.3	44.7
	10	54.4	—	83.9	84.7	70.3	80.3	75.8	30.1
	11	68.9	51.7	81.8	85.5	84.6	89.7	73.7	55.0
	11	69.2	35.1	79.3	82.3	77.9	84.5	68.9	48.0
	13	65.8	39.9	82.6	84.0	81.4	76.7	75.2	28.0
	14	64.8	35.6	82.8	81.9	75.0	76.7	67.4	46.5
	15	72.0	23.4	81.9	67.9	80.6	83.4	84.1	31.1
	16	73.6	53.4	84.8	90.7	89.6	87.1	83.4	45.0
Crude Fibre	9	24.5	53.2	27.0	22.1	32.9	26.8	49.6	42.5
	10	26.4	—	10.5	23.9	30.3	28.7	49.0	43.4
	11	20.7	46.0	10.7	18.7	22.3	26.6	43.9	37.0
	12	20.2	41.2	17.7	21.8	38.1	29.0	39.6	37.5
	13	22.6	45.6	15.1	20.6	30.3	27.6	44.9	40.0
	14	24.9	28.7	5.1	15.2	36.6	33.2	42.0	47.8
	15	22.2	37.2	9.7	25.4	30.4	37.0	40.7	42.5
	16	30.1	36.2	12.7	17.6	35.5	31.9	39.4	49.2
Nitrogen-free extract	9	89.9	94.1	86.7	84.1	88.2	86.9	91.1	89.7
	10	90.1	—	87.4	82.8	88.1	87.7	90.7	90.6
	11	90.5	92.9	87.4	79.9	87.5	87.6	90.1	90.0
	12	89.5	93.2	85.4	79.8	86.3	87.0	89.0	90.2
	13	89.0	92.9	85.1	78.6	87.4	87.1	89.6	90.0
	14	89.0	93.1	85.8	78.6	87.1	87.0	89.2	90.7
	15	89.4	93.0	85.1	81.8	87.6	88.1	90.4	90.2
	16	90.3	94.2	84.3	79.7	87.6	86.9	89.7	89.9

TABLE 7.—COEFFICIENTS OF DIGESTIBILITY OF THE VEGETABLE PROTEIN CONCENTRATES CALCULATED FROM MIXED RATIONS WITH BARLEY

(Coefficients in %)

Feed	Period	Coefficients of Digestibility of Nutrients					
		Dry Matter	Organic Matter	Nitrogen	Ether Extract	Crude Fibre	N-Free Extract
Soybean Oil Meal I	9	93.1	94.4	91.8	97.7	94.2	96.6
	10	89.4	90.4	86.2	81.8	94.6	95.0
	11	86.4	87.6	86.0	78.5	78.3	91.6
	12	82.6	84.0	85.5	70.3	67.6	86.0
	13	87.1	88.4	88.5	80.8	83.1	89.2
	14	82.3	83.7	83.4	67.8	76.2	87.3
	15	86.9	88.9	85.9	95.3	69.6	92.9
	16	85.8	87.6	87.0	94.3	68.6	89.9
Soybean Oil Meal II	9	82.2	84.6	83.2	— 37.5	77.6	89.9
	10	88.8	90.1	90.4	—400.0	80.6	94.0
	11	89.5	90.4	95.2	— 55.0	60.7	91.2
	12	88.9	90.2	93.0	—114.3	63.2	92.0
	13	85.9	87.4	88.8	—248.3	69.5	91.3
	14	91.2	92.3	93.2	—106.7	93.8	94.4
	15	86.1	88.0	88.4	—223.3	76.9	91.8
	16	86.8	88.4	87.5	—109.7	96.3	90.7
Linseed Oil Meal I	9	76.9	79.2	82.6	90.8	43.9	83.3
	10	76.7	78.9	85.0	72.5	38.3	82.7
	11	70.7	74.2	79.5	96.1	20.2	80.0
	12	74.5	76.6	82.5	85.4	55.0	75.1
	13	76.7	79.1	87.6	89.9	37.8	79.8
	14	74.5	76.6	81.7	79.6	53.7	78.3
	15	73.9	76.3	80.6	88.7	37.9	80.6
	16	75.6	78.2	79.2	102.9	49.7	80.3
Linseed Oil Meal II	9	72.7	75.0	83.5	90.7	30.2	77.3
	10	74.7	77.2	82.9	86.7	34.4	81.0
	11	74.4	77.4	81.6	102.5	29.8	80.1
	12	74.2	76.5	81.2	94.8	35.1	78.1
	13	73.5	76.2	83.7	82.5	32.0	78.3
	14	72.5	74.7	79.2	81.6	45.0	77.9
	15	79.1	81.3	84.3	91.8	52.6	82.9
	16	72.5	75.3	78.8	97.8	42.2	77.9

SUMMARY

Using an 8×8 randomized Latin square, coefficients of digestibility were determined with growing swine for the following feeds: soybean oil meal (expeller process), soybean oil meal (solvent process), linseed oil cake meal (two lots), buckwheat, rye, screenings and barley.

During the 26 weeks of the experiment, the digestibilities of the feeds were not affected by the increasing weights of the animals.

There were no marked differences between the various animals in their ability to digest the feeds.

Values for the total digestible nutrients and digestible protein of the 8 feeds were listed.

ACKNOWLEDGMENT

Technical assistance was given by June Andrews and W. Angus of the Division of Chemistry.

REFERENCES

1. CRAMPTON, E. W., and FRANK WHITING. The Digestibility of Typical Eastern Canadian Feeds by Market Bacon Hogs. II. *Scientific Agriculture*, 23 : 725-731. 1943.
2. JONES, D. BREESE. Factors for Converting Percentages of Nitrogen in Foods and Feeds into Percentages of Proteins. United States Dept. of Agriculture, Washington, D.C. Circular No. 183.
3. WATSON, C. J., J. A. CAMPBELL, W. M. DAVIDSON, C. H. ROBINSON, and G. W. MUIR. Digestibility Studies with Swine. I. The Digestibility of Grains and Concentrates at Different Stages of the Growing and Fattening Period. *Scientific Agriculture*, 23 : 708-724. 1943.
4. YATES, F. The Analysis of Replicated Experiments when the Field Results are Incomplete. *Empire Jour. Exp. Agric.*, 1 : 129-142. 1933.

MALTING QUALITY OF CANADIAN BARLEYS: V. SUMMARY OF SEVEN YEARS TESTS ON MONTCALM, A NEW SMOOTH AWNED VARIETY¹

W. O. S. MEREDITH²

Grain Research Laboratory, Board of Grain Commissioners for Canada, Winnipeg

[Received for publication August 16, 1946]

The object of this series of papers is to record information on the malting quality of varieties of barley grown in Canada. The Canadian barley grading system takes into account the relative malting quality of varieties and excludes poor varieties from the higher grades, thus information on new varieties is of interest and value to users of Canadian barley. Only a few of the varieties discussed in previous papers of this series (3, 4, 9, 10) enter commercial channels, and the information has been of more value to plant breeders than to the barley trades. The former required information on the relative merits for malting purposes of the more common varieties that were being used in breeding programmes. This is the first in a series of papers dealing with a variety which is expected to make a significant contribution to top grades of barley. This variety, Montcalm, is a smooth awned variety with a blue aleurone layer that was produced by Professor Emile A. Lods, Macdonald College, Quebec. Its origin is (Michigan 31604 $\times$ Common Six-row) $\times$ Mandscheuri, and the original cross was made in 1922. Malting tests have been made on Montcalm in comparison with O.A.C. 21 each year since 1939, and a summary of the results is now presented. The malting quality of Montcalm is satisfactory and the Board of Grain Commissioners have ruled that the variety is eligible for the highest grades of six-row barley.

The data represent comparisons of Montcalm and O.A.C. 21 over a period of 7 years, during which 77 pairs of samples were tested. Eight stations in Eastern Canada and 18 stations in Western Canada submitted samples during the 7 years of testing, so that a considerable range of environment is represented in the study. It is thus possible to obtain a fairly comprehensive picture of the performance of Montcalm in comparison with that of O.A.C. 21. The terms used in discussing malting quality have been reviewed and explained in previous papers (3, 4, 9, 10) and need not be discussed further in this.

MATERIALS AND METHODS

The barley samples were collected from various agronomic trials conducted during the years 1939-1945. The number of samples tested in each year, and the stations represented, are given in Table 1. The agronomic trials were conducted in the same manner as in previous years (3, 4, 9) and the grain from replicate plots was bulked to provide the amount of material required for malting tests.

¹ Contribution from the Grain Research Laboratory, Board of Grain Commissioners for Canada, Winnipeg. Published as Paper No. 245 of the Associate Committee on Grain Research and as G.R.L. No. 89. Presented in part at Annual Meeting of American Society of Brewing Chemists, Milwaukee, Wis., U.S.A., May, 1946.

² Chemist, Grain Research Laboratory, Board of Grain Commissioners for Canada, Winnipeg, Manitoba.

TABLE 1.—NUMBER OF SAMPLES TESTED IN EACH YEAR, AND LOCATION AT WHICH GROWN

Year	No. of samples	No. of stations	Stations
1939	3	3	Ste. Anne de la Pocatiere, Macdonald College, Lennoxville.
1940	3	3	Ste. Anne de la Pocatiere, Macdonald College, Lennoxville.
1941	8	8	Ste. Anne de la Pocatiere, Macdonald College, Lennoxville, Ottawa, Almonte, Kemptville, Manotick, Guelph.
1942	5	5	Ste. Anne de la Pocatiere, Macdonald College, Lennoxville, Ottawa, Guelph.
1943	8	8	Ste. Anne de la Pocatiere, Macdonald College, Lennoxville, Guelph, Winnipeg, Brandon, Edmonton, Fallis.
1944	23	17	Ste. Anne de la Pocatiere, Macdonald College, Lennoxville, Guelph, Brandon, Goodlands, Melita, Swan River, Tisdale, Indian Head, Edmonton, Fallis, Athabaska, Bon Accord, Warburg, Sundre, Lacombe.
1945	27	17	Ste. Anne de la Pocatiere, Macdonald College, Lennoxville, Winnipeg, Brandon, Goodlands, Melita, Swan River, Kemptville, Tisdale, Indian Head, Melfort, Edmonton, Fallis, Lacombe, Bowden, Cremona.

TABLE 2.—COMPARISON OF BARLEY, MALTING AND MALT PROPERTIES OF O.A.C. 21 AND MONTCALM, AS MEANS OVER 7 CROP YEARS

Property	O.A.C. 21	Montcalm
BARLEY		
Bushel weight, lb.	50.4	50.7
Plump barley, %	80.2	86.5
1000 kernel wt., gm.	33.2	33.8
Nitrogen, %	2.29	2.16
MALTING		
Hours steep	56.0	57.0
Malting loss, %	9.0	9.0
MALT		
Extract, %	75.4	76.4
Saccharifying activity, ° L.	122.0	129.0
Wort nitrogen, %	1.21	1.12
Index of nitrogen modification, %	39.7	39.8
Number of samples	77	77

Malting

The samples were prepared for malting and malted by the standard methods (9) and with equipment that has been described previously (2, 5, 8).

Analysis

The commonly measured properties of barleys and malts were determined by the standard procedures previously described (9). Additional barley, malt, and wort properties were determined by the methods described in another series of papers (1, 6, 7, 11, 13, 14). Alpha amylase activity was determined by the methods of other workers (12, 15).

TABLE 3.—COMPARATIVE BARLEY, MALTING AND MALT PROPERTIES OF MONTCALM
EXPRESSED AS DIFFERENCES FROM CORRESPONDING MEAN
VALUE FOR O.A.C. 21 IN EACH YEAR

Year	No. of samples	Barley				Malting		Malt			
		Bu. wt.	Heavy grade	1000 K. wt.	Nitrogen	Hrs. steep	Malting loss	Extract	Sacchari-fying activity	Wort nitrogen	Index of nitrogen modification
		lb.	%	g.	%		%	%	° L.	%	%
1939	3	—	2.8	0.9	-0.04	0	-0.4	1.0	3	-0.07	-1.4
1940	3	—	6.6	0.2	-0.13	-2	0.3	1.2	21	-0.15	-2.3
1941	8	—	15.3	1.8	-0.20	3	0.3	1.7	3	-0.07	2.3
1942	5	—	5.1	0.8	-0.10	3	0.1	0.9	10	-0.08	-0.3
1943	8	—	4.4	-0.1	-0.18	0	0.1	1.7	1	-0.11	0.6
1944	23	0.2	3.9	0.3	-0.12	0	0.2	0.8	10	-0.07	0.2
1945	27	0.4	7.0	0.9	-0.11	3	-0.2	0.8	5	-0.08	-0.5

RESULTS AND DISCUSSION

The data from the determinations made on the 77 pairs of samples are so numerous that it is necessary to present them only in summary form. The direct comparisons of the mean values of O.A.C. 21 and Montcalm for the commonly measured properties are given in Table 2.

These data show that Montcalm is slightly higher than O.A.C. 21 in bushel weight, definitely higher in yield of heavy grade barley suitable for malting, slightly higher in kernel weight, and definitely lower than the standard variety in barley nitrogen content. These features, all advantageous, show that Montcalm therefore possesses satisfactory barley properties. The two varieties are practically identical in properties measured during malting, viz., length of steep required to reach 44% moisture content, and amount of loss due to respiration and roots. Similarity in these properties, among varieties eligible for the same grades, is essential for successful malting as farmers' deliveries of the same grade are mixed at country elevators and carlots of the same grade are mixed at terminal elevators. If two varieties of dissimilar characteristics are mixed, considerable difficulties are encountered in malting as one variety may be understeeped and the other may be oversteeped; there would also be further trouble in the floor on account of irregular growth. The similarity in the steep and growth rates of Montcalm to those of O.A.C. 21 should therefore permit satisfactory malting of the mixture of these varieties that will occur.

The actual malt properties of Montcalm are of principal interest. The data show that Montcalm is 1% higher than O.A.C. 21 in malt extract and slightly higher in saccharifying activity. The value for wort nitrogen content of Montcalm is somewhat lower than that for O.A.C. 21, but the difference is accounted for by the difference in barley nitrogen. This is shown by the data for index of nitrogen modification which represents the proportion of original nitrogen content that is made soluble during malting and mashing. The malt qualities of Montcalm are thus fully equal to those of O.A.C. 21, in fact, Montcalm can be considered superior to O.A.C. 21. A point of interest is that, despite the fact that Montcalm is lower than O.A.C. 21 in nitrogen content, it is higher in saccharifying activity.

Usually, though more generally within a variety, low nitrogen content is accompanied by low enzymatic activity. The data thus show that Montcalm represents a marked advance in quality from the status described a few years ago (3, 10) when the smooth awned varieties as a class were characterized by low malt extract content and low enzymatic activity.

It is also important to determine the consistency of Montcalm in relation to O.A.C. 21 over the test period. Data on this point are given in Table 3. In this table the mean values, for each year, for Montcalm are expressed as differences from the mean values for O.A.C. 21. A negative sign indicates that the value for Montcalm is lower than that for O.A.C. 21, while absence of sign indicates that the Montcalm value is higher. In order that the absolute values for Montcalm may be ascertained, the mean values for each year for O.A.C. 21 are given in Table 4.

The data given in Table 3 show that Montcalm is very consistent in its properties when the values are expressed as differences from O.A.C. 21. O.A.C. 21 is considered to be a very stable variety in its reaction to change in environment (3), and Montcalm is in the same class as the standard. The detailed data for the 77 individual pairs of samples, which are not given in this paper, show that this consistency is evident throughout the entire series of samples.

The properties discussed up to this point are those that are studied during routine malting tests and are measured on the barley, during malting, and on the malts. On the basis of these measurements, primary separation of barley varieties into "not promising" and "promising" classes are made. Such classifications were made in the first four papers in this series (3, 4, 9, 10) and they are adequate for decisions on inferior varieties. However, even when a variety compares favourably with O.A.C. 21 in the properties commonly measured, there is no real certainty that the variety will find acceptance in commercial malting and brewing. In order that varietal recommendations can be made with more certainty, additional properties that have some bearing on malting quality and on commercial utilization are studied.

The values for O.A.C. 21, and Montcalm, for a number of additional barley, malt and wort properties, are listed in Table 5. The significance of these properties has been reviewed in other papers (1, 6, 7, 11, 13, 14).

TABLE 4.—BARLEY, MALTING AND MALT PROPERTIES OF O.A.C. 21,
MEAN VALUES FOR EACH OF 7 YEARS

Year	No. of samples	Barley				Malting		Malt			
		Bu. wt.	Heavy grade	1000 K. wt.	Nitrogen	Hrs. steep	Malting loss	Extract	Saccharifying activity	Wort nitrogen	Index of nitrogen modification
		lb.	%	g.	%		%	%	° L.	%	%
1939	3	—	88.2	33.5	2.14	60	8.4	75.0	121	1.16	41.1
1940	3	—	77.2	33.1	2.09	59	10.0	75.4	113	1.19	42.9
1941	8	—	67.3	30.6	2.39	52	12.3	74.8	156	1.30	40.7
1942	5	—	81.1	34.2	2.06	58	9.3	76.6	113	1.19	44.2
1943	8	—	85.0	34.2	2.23	60	8.3	75.6	119	1.21	41.0
1944	23	50.6	82.0	34.0	2.24	60	8.7	75.6	112	1.18	39.8
1945	27	50.2	80.2	32.7	2.41	50	8.4	75.1	124	1.21	37.8

Many of the determinations were made on samples representing two crops, 1941 and 1945, so that again there is information on the stability of Montcalm in relation to O.A.C. 21. The results in Table 5 show that, aside from differences in total and salt-soluble barley nitrogen and in wort nitrogen, the two varieties are essentially similar in properties. Actually, practically all the comparisons are in favour of Montcalm. The turbidity data show that Montcalm wort is slightly more turbid than O.A.C. 21 wort, when examined immediately after filtration, but the differences are small and actually not discernible without the use of special instruments. After standing, the turbidity of Montcalm wort is lower than O.A.C. 21 wort, which represents greater wort stability.

TABLE 5.—COMPARISON OF O.A.C. 21 AND MONTCALM IN A NUMBER OF ADDITIONAL BARLEY AND MALT PROPERTIES

Property	1941 Crop, 8 samples		1945 Crop, 10 samples	
	O.A.C. 21	Montcalm	O.A.C. 21	Montcalm
BARLEY				
Total nitrogen, %	2.39	2.18	2.40	2.28
Salt soluble nitrogen, %	0.63	0.59	—	—
Saccharifying activity, ° L.	219	217	221	230
Extract, %	74.9	76.8	75.2	76.8
MALT				
Saccharifying activity, ° L.	156	159	127	132
Autolytic saccharifying activity, mg. maltose	715	808	—	—
Alpha amylase activity	55 ¹	56 ¹	97 ²	100 ²
Proteolytic activity, mg./100 gm.	221	239	—	—
WORT				
Nitrogen, %	1.30	1.23	1.21	1.12
Attenuation, %	80.1	82.7	85.9	89.0
Viscosity	1.444	1.417	1.492	1.467
Initial turbidity, %	17	26	26	29
Turbidity after 24 hours, %	148	124	211	197

¹ Nebraska units.

² Wisconsin units, mg. maltose.

The summation of the properties studied, therefore, indicates that Montcalm is of the same type as O.A.C. 21 in malting quality. Moreover, Montcalm is superior to O.A.C. 21 in malt extract and saccharifying activity. These two properties are important in industrial use and present indications are that Montcalm will be accepted with favour by commercial maltsters. Several companies in Canada and the United States have malted small samples of Montcalm and regard the results with satisfaction. No large lots of Montcalm have been malted and brewed as yet, but from pilot plant tests made in an industrial laboratory it was concluded that Montcalm and O.A.C. 21 produce similar results in the brewhouse.

SUMMARY

The results of malting tests made on 77 paired samples of O.A.C. 21 and Montcalm over a period of 7 crop years are summarized. Montcalm compares very favourably with O.A.C. 21 in all properties measured. It yields a somewhat higher percentage of heavy grade barley suitable for malting than does O.A.C. 21, and its kernels are slightly larger. The

barley nitrogen content of Montcalm is lower than that of O.A.C. 21, yet Montcalm appears to be adequately supplied with enzymes. As a result, Montcalm is about 1% higher than O.A.C. 21 in malt extract. The two varieties are identical in steep requirements and growth rate, and no difficulty is anticipated in malting mixtures of the varieties. A number of additional barley, malt and wort properties were examined, and Montcalm compares favourably with O.A.C. 21 in these. It is concluded that Montcalm is fully equal to O.A.C. 21 in malting quality.

ACKNOWLEDGMENTS

The author is particularly indebted to Mr. P. R. Cowan, Central Experimental Farm, Ottawa, who arranged for the growing and collection of most of the samples. The co-operation of the staffs of the agricultural stations listed in Table 1, and the assistance of Mr. K. Hlynka and Mrs. L. K. S. Sackston, who conducted the malting tests on the samples representing the years 1941 to 1944, are gratefully acknowledged. The suggestions of Dr. J. Ansel Anderson during the preparation of the manuscript are appreciated.

REFERENCES

1. ANDERSON, J. A. and C. A. AYRE. Varietal differences in barleys and malts. I. Nitrogen distribution among protein fractions of barley. *Can. Jour. Research*, C. 16 : 377-390. 1938.
2. ANDERSON, J. A., and W. O. S. MEREDITH. Laboratory Malting. III. Steeping Equipment and Method. *Cereal Chem.* 17 : 66-72. 1940.
3. ANDERSON, J. A., W. O. S. MEREDITH, and H. R. SALLANS. Malting quality of Canadian Barleys. IV. A summary of information of special interest to plant breeders. *Sci. Agr.* 23 : 297-314. 1943.
4. ANDERSON, J. A., and H. ROWLAND. Studies on malting quality. I. 1935 Variety trials. *Sci. Agr.* 17 : 593-600. 1937.
5. ANDERSON, J. A., and H. ROWLAND. Modified equipment and methods for the routine malting test and a study of its precision. *Sci. Agr.* 17 : 742-751. 1937.
6. AYRE, C. A., and J. A. ANDERSON. Varietal differences in barleys and malts. VI. Autolytic proteolytic activity of malt and its correlations with wort nitrogen and barley nitrogen fractions. *Can. Jour. Research*, C. 17 : 239-246. 1939.
7. AYRE, C. A., H. R. SALLANS, and J. A. ANDERSON. Varietal differences in barleys and malts. IX. Carbohydrate fractions of barley and their correlations with total nitrogen and 1000-kernel weight. *Can. Jour. Research*, C. 18 : 169-177. 1940.
8. MEREDITH, W. O. S., K. HLYNKA, and H. R. SALLANS. Laboratory Malting. IV. A germination chamber for routine malting tests. *Cereal Chem.* 21 : 251-258. 1944.
9. MEREDITH, W. O. S., H. ROWLAND, and J. A. ANDERSON. Malting quality of Canadian barleys. II. Nineteen varieties, 1936 and 1937 trials. *Sci. Agr.* 19 : 389-403. 1939.
10. MEREDITH, W. O. S., H. ROWLAND, and H. R. SALLANS. Malting quality of Canadian barleys. III. Twenty-eight varieties, 1938, 1939, and 1940 trials. *Sci. Agr.* 22 : 584-593. 1942.
11. MEREDITH, W. O. S. and H. R. SALLANS. Varietal differences in barleys and malts. XIII. Wort attenuation, viscosity, and turbidity, and their inter-relations. *Can. Jour. Research*, C. 21 : 351-362. 1943.
12. OLSON, W. J., R. EVANS, and A. D. DICKSON. A modification of the Kneen and Sandstedt methods for the determination of Alpha- and Beta-amylases in barley malt. *Cereal Chem.* 21 : 533-539. 1944.
13. SALLANS, H. R. and J. A. ANDERSON. Varietal differences in barleys and malts. II. Saccharifying activities of barleys and malts and the correlations between them. *Can. Jour. Research*, C. 16 : 405-416. 1938.
14. SALLANS, H. R., and J. A. ANDERSON. Varietal differences in barleys and malts. VII. Starch liquefying activity, autolytic diastatic activity, and their correlations with saccharifying and proteolytic activity. *Can. Jour. Research*, C. 17 : 361-372. 1939.
15. SANDSTEDT, R. M., E. KNEEN, and M. J. BLISH. A standardized Wolgemuth procedure for alpha amylase activity. *Cereal Chem.* 16 : 712-723. 1939.

THE EFFECT OF PHOSPHATIC FERTILIZERS ON SUMMER-FALLOW WHEAT CROPS IN CERTAIN AREAS OF SASKATCHEWAN¹

J. MITCHELL²

University of Saskatchewan, Saskatoon, Saskatchewan

[Received for publication July 29, 1946]

The use of phosphatic fertilizers is becoming a standard practice on many farms in Saskatchewan. This development is a relatively recent one, there being little commercial fertilizer used previous to the year 1927 when high analysis fertilizers were first introduced, and the principle of drilling the fertilizer with the seed was accepted. From 1927 until recent years the use of phosphates has tended to increase but slowly, partly because of the discouraging dry years of the thirties. It is only the past few years that there has been any marked increase in tonnage used, although results obtained in a series of trials conducted co-operatively between Dominion and Provincial Depts. of Agriculture, Universities and commercial firms during 1928-1930 (6) were quite encouraging to the use of phosphates in the Prairie Provinces.

It is not unusual to find comparatively fertile soils such as are common to this area responding to phosphates after some 30 to 40 years of cultivation. Bear (1) states that "it is a matter of common experience that soils become deficient in available phosphorus early in their agricultural history," and Russell (9) mentions phosphate deficiency as being common to many parts of the world. Truog (12) states that the minimum amount of available phosphorus sufficient for a crop depends upon the kind of crop, the soil and the climate. All three factors mentioned by Truog are well recognized, but it is doubtful if the factor of climate at least has generally been given sufficient emphasis. The effect of phosphates in hastening ripening is of immense importance in areas where growing seasons are short. Earliness may have other important effects such as avoidance of rust damage, escaping of insect attack, and in some seasons avoiding the full impact of a period of drought. However, if drought occurs too early in growth, the fertilized fields commonly suffer the effects of hot dry weather as do the unfertilized crops, but the yield of the former is not necessarily reduced to that of the latter (9). The beneficial value of phosphates in combatting the effect of root rots has been reported by Vanterpool (14) and Russell and Sallans (10). Godel (3) reports that treated crops are enabled to compete more successfully with weeds.

The total phosphorus in Saskatchewan soils (13) ranges from 0.03 to 0.10% except in rare cases, and by far the larger number of analyses show results between 0.05 and 0.08%. Therefore, the percentage of elemental phosphorus in these soils is not unusually high (11) and such amounts of phosphorus were undoubtedly originally present in many soils which, with

¹ Contribution from Dept. of Soils, University of Saskatchewan, Saskatoon, Sask.

² Professor of Soils, University of Saskatchewan, Saskatoon, Sask.

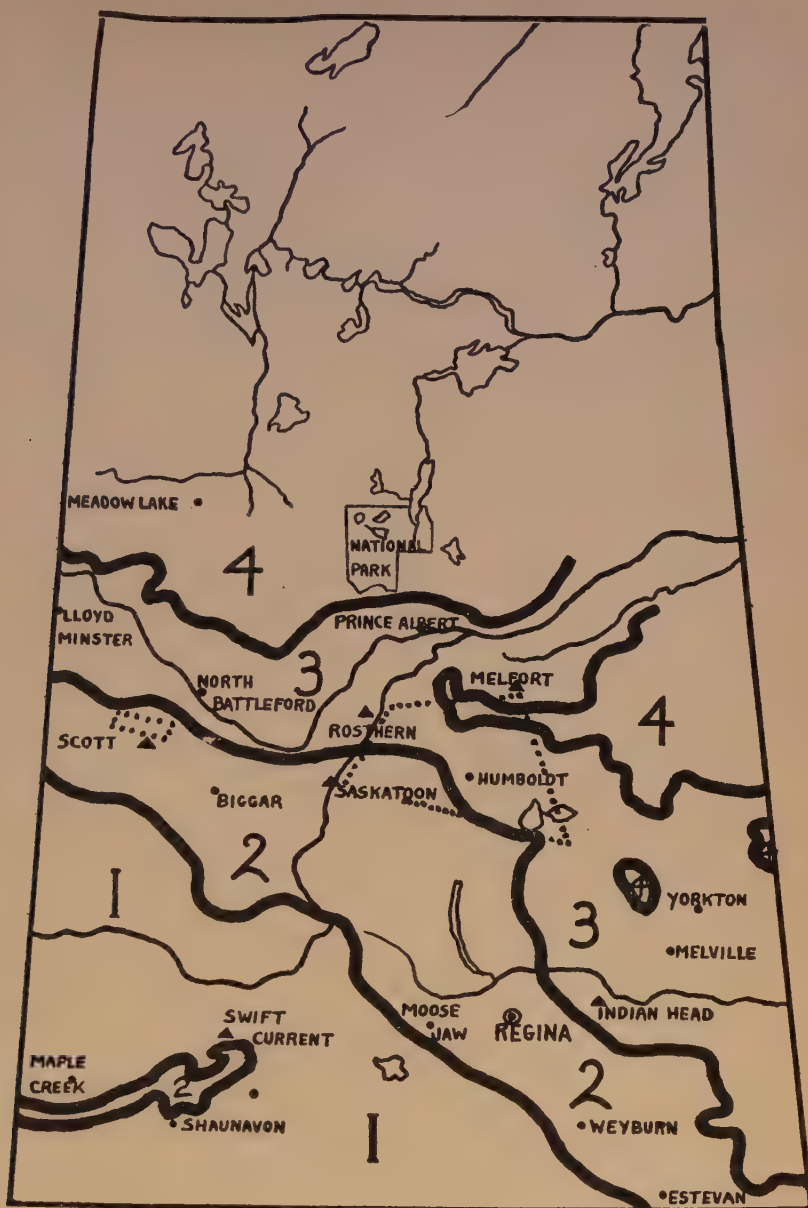


FIGURE 1. Sketch Map Showing Soil Zones of Saskatchewan and General Location of Test Plots.

LEGEND

1. Brown Soils—short grass prairie and western section of mixed prairie.
2. Dark Brown Soils—mixed prairie grass section.
3. Black Soils—"Park Belt" or "Aspen Grove" section.
4. Grey (podzolic) Soils—forested section.

..... Boundary of area within which test plots were located.

* Adapted from Sask. Soil Survey Report No. 12 (4).

only a slightly longer cropping history, are now giving good responses to fertilization. The "availability" of the phosphorus is much more variable (5) than is the total phosphorus. In general the leached soils such as podzols and solods have the lowest availability (13), and heavy soils commonly are higher in "available" phosphorus than are sandy ones. The availability is lowest in soils with well developed A_2 horizons, and is often very low in such horizons.

The variability of climatic conditions across Saskatchewan is a factor not readily appreciated. The factor of rainfall has been overstressed and the importance of temperature, humidity and wind velocity has not been given sufficient attention. The average annual rainfall varies between 11 in. and 19 in. but Swift Current with an average rainfall of 15.18 in. is in the brown soils zone of the Prairie-plains while Prince Albert with only 15.87 in. rainfall is on the border of the podzolic soil zone, and the mixed wood forest. Climatic conditions are entirely different at these places, and so therefore is the general character of soil and vegetation. Plainly, these differences are not due to rainfall alone.

Southwestern Saskatchewan is the most arid area of the province, the aridity decreasing towards the north and east. At the same time average temperatures are much lower towards the north, and growing seasons shorter, although this trend is less marked towards the east. Variability of seasons is also greatest in the warmer and drier southwest and lessens towards the north and east. Table 1 gives average annual temperatures and average precipitation for Swift Current in the brown soil zone (see Figure 1), Saskatoon in the dark brown, Melfort in the black, and Prince Albert on the border of the gray wooded zone. A study of these data clearly indicate the relative importance of temperature as compared to rainfall in considering the climate of the various areas within this province. These variations in temperature and precipitation give rise to well defined climatic, soil, and vegetational zones within the province (Figure 1) and are of significance in relation to cropping practices, and in the results reported herein relative to the use of phosphates.

SCOPE AND PLAN OF EXPERIMENTS

The purpose of these experiments was to test in the field three common kinds of phosphatic fertilizers at several rates, so that differential responses due to rates and kind could be measured. In addition, the matter of variability of response on different soils, and in different seasons was kept in mind throughout the investigation. The results reported herein were obtained during the seasons of 1939 to 1943.

Since it was deemed desirable that the data should reflect as closely as possible results which the farmer might obtain, the following plan was adopted. Each treatment was seeded a drill width the length of the field selected. The farmer's own drill and attachment were used, or an attachment was supplied in cases where the farmer did not own one. A check strip was left adjacent to each treated strip. When harvesting, 10 individual square yard samples were taken from each strip. Each sample was threshed and weighed separately. Students' pairing method was used in calculating the statistical significance of results.

Three kinds of fertilizers were used in the trials, each applied at 4 rates, as follows:—

Fertilizer	(Lb. per acre)			
	Rate 1	Rate 2	Rate 3	Rate 4
11-48-0	15	25	35	50
0-43-0 ¹	17	28	40	56
2-20-0 ²	15	25	35	75

¹ In last year of experiments 0-43-0 was no longer available, so 0-38-0 was used at 19, 32, 44 and 63 lb. per acre.

² A 2-19-0 fertilizer was used for the first 2 years of trials.

It may be pointed out that exact rates could not be obtained under the conditions of the tests. However, variations were kept as small as practicable by checking the amount passing through the attachment and adjusting to as near the desired rate as possible.

The triple super-phosphate was applied at rates giving equivalent amounts of P_2O_5 to comparable rates of 11-48-0.

The first 3 rates of 2-20-0 were applied at the same rates as the 11-48-0 to give a direct comparison between lower analysis and higher analysis fertilizers, and to furnish an opportunity to study the effect of still lower applications of P_2O_5 . The fourth rate of 2-20-0 (75 lb. per acre) was intended to apply equal amounts of P_2O_5 to that applied in the third rate 40 lb. per acre, but some difficulty was encountered in applying the material with the attachments used. The 75 lb. rate of 2-20-0 gives an application of 15 lb. of P_2O_5 and 1.5 lb. of nitrogen compared to the 40 lb. rate of 0-43-0 which gives 17 lb. of P_2O_5 .

All trials were on wheat seeded on summerfallowed land, since experience indicated that fertilization was ineffective on second crops. This matter deserves further investigation since there is little doubt that favourable responses are obtained on other than summerfallow land in districts where more favourable moisture conditions obtain. No attempt was made to check residual effects of the fertilizer. Results from the Dominion Experimental Station at Swift Current in the drier brown soil zone (Figure 1) are not encouraging to the use of fertilizer even on summerfallow crops (7). These trials were therefore confined to the area indicated in Figure 1 touching on three major soil zones, namely, the dark brown, black, and gray wooded (podzolic) soils. The largest number of experiments were on black soils with slightly fewer on the dark brown, only 4 experiments were on gray wooded soils. Three trials were situated in the western section of the dark brown soil zone near the towns of Wilkie and Unity.

Types of soils on which trials were placed included those most prominent in the area. In the dark brown soil zone the trials were on medium textured soils of the Weyburn and Elstow associations, with the exception of two on the lighter textured Asquith and three on Elstow clay out of a total of 23 sets of plots.

In the black soil zone the tests were mainly on medium textured soils. However, these soils were of two distinct types; namely, high lime and normal types. The high lime types included Yorkton, Canora and Cudworth Associations on which there were 22 trials. The non-limy were the Naicam, Oxbow and Melfort on which there were 26 trials. The high lime group are rendzina-like soils containing lime throughout the profile or at least into the lower A horizon. The non-limy soils have no free lime in the A or B₁ horizons and might be considered normal regional soils. There is, of course, a lime layer present in the lower B horizon of the latter soils. The aforementioned soils are described in Soil Survey Report No. 12, University of Saskatchewan (4).

Only four trials were situated on podzolized soils, the soils represented being the Whitewood and Waitville loams.

NATURE OF SEASONS DURING WHICH TRIALS WERE CARRIED ON

The weather through three of the seasons of the tests was quite typical for the area. These were 1939, 1940 and 1942. The seasons of 1941 and 1943 were quite dry in the area of the tests, but the season of 1941 was one of higher than average temperatures as well as of low rainfall. This fact will be referred to later in discussing the results of the tests. For comparison, the average temperatures and total precipitation for the month of June and July in the seasons of these tests are given in Table 2.

Table 3 shows the average increase obtained for each fertilizer at the various rates in the seasons 1939-1943. The percentage increase over check plots is also shown and the number of plots of each rate which gave highly significant, significant, or not significant increases. Detailed results of individual tests have already been published in mimeograph form for each season except for the last year of the trials (8).

TABLE 1.—AVERAGE ANNUAL TEMPERATURE AND ANNUAL PRECIPITATION AT SWIFT CURRENT, SASKATOON, MELFORT AND PRINCE ALBERT

—	Soil zone	Average temperature	Average precipitation
Swift Current	Brown	38.10°	15.18 in.
Saskatoon	Dark brown	33.30°	14.80 in.
Melfort	Black (deep)	31.10°	15.25 in.
Prince Albert	Border of gray wooded	31.60°	15.87 in.

TABLE 2.—AVERAGE TEMPERATURE AND PRECIPITATION FOR JUNE AND JULY IN SEASONS 1939-1943, WITHIN AREA OF TESTS (DATA FROM 7 DOMINION METEOROLOGICAL STATIONS WITHIN AREA)

—	June		July	
	Average temperature	Precipitation	Average temperature	Precipitation
1939	53.6°	6.1 in.	65.6°	2.1 in.
1940	56.6°	3.4 in.	63.2°	2.5 in.
1941	62.3°	2.0 in.	68.1°	1.7 in.
1942	57.6°	5.6 in.	61.5°	2.6 in.
1943	54.6°	1.3 in.	65.7°	1.8 in.

TABLE 3.—AVERAGE INCREASES FOR THREE FERTILIZERS AT 4 RATES FOR 1939 TO 1943

—	Fertilizer	Rate per acre	Total number of plots	Average bu. increase per acre	% increase	Number of results:		
						Highly significant	Significant	Not significant
1939	11-48-0	15#	19	8.6	29.5	14	3	2
		25	20	9.9	34.0	13	1	6
		35	21	11.2	38.5	14	4	3
		50	20	13.0	44.0	16	3	1
	0-43-0	17	20	5.9	22.0	10	1	9
		28	21	7.2	25.0	13	3	5
		40	21	9.0	31.0	12	6	3
		56	21	10.3	35.5	16	1	4
	2-19-0	15	20	2.4	8.3	0	3	17
		25	21	4.6	15.8	6	4	11
		35	21	4.5	15.5	5	6	10
		75	20	7.0	24.0	11	3	6
1940	11-48-0	15	14	6.5	24.5	7	0	7
		25	14	10.2	38.5	12	1	1
		35	14	11.5	42.5	10	2	2
		50	14	12.2	46.0	10	3	1
	0-43-0	17	14	5.3	20.0	5	2	7
		28	14	8.6	32.5	8	4	2
		40	14	10.7	40.0	11	2	1
		56	14	12.7	48.0	13	1	0
	2-19-0	15	14	2.4	9.0	1	2	11
		25	14	3.7	14.0	5	1	8
		35	14	4.5	17.0	3	4	7
		75	14	6.6	25.0	8	2	4
1941	11-48-0	15	14	3.5	19.5	6	3	5
		25	14	2.8	17.0	3	5	6
		35	14	2.0	12.0	3	3	8
		50	15	4.5	25.0	7	3	5
	0-43-0	17	15	2.5	14.0	5	3	7
		28	15	2.4	13.5	2	1	12
		40	15	3.9	22.0	4	3	8
		56	15	3.7	21.0	5	5	5
	2-20-0	15	15	0.5	2.7	2	2	11
		25	15	0.8	4.5	0	1	14
		35	15	0.9	5.0	0	1	14
		75	15	1.2	6.8	1	1	13
1942	11-48-0	15	14	9.6	36.0	11	2	1
		25	15	11.3	42.5	13	1	1
		35	15	12.1	45.5	13	1	1
		50	15	13.4	50.0	13	1	1
	0-43-0	17#	15	5.4	20.0	8	3	4
		28	15	7.0	26.5	9	3	3
		40	15	9.8	37.0	12	2	1
		56	15	12.6	47.5	15	0	0
	2-20-0	15	15	3.3	12.5	4	2	9
		25	15	4.3	16.0	5	4	6
		35	15	5.2	19.5	5	4	6
		75	15	7.6	28.5	10	3	2

TABLE 3.—AVERAGE INCREASES FOR THREE FERTILIZERS AT 4 RATES FOR 1939 TO 1943—*Continued*

—	Fertilizer	Rate per acre	Total number of plots	Average bu. increase per acre	% increase	Number of results:		
						Highly significant	Significant	Not significant
1943	11-48-0	15	10	4.6	27.0	6	0	4
		25	10	5.4	31.5	7	1	2
		35	10	5.6	33.0	6	1	3
		50	10	8.2	48.0	9	0	1
	0-38-0	19	10	3.7	21.5	2	2	6
		32	10	5.0	29.0	5	1	4
		44	10	5.6	33.0	8	0	2
		63	10	7.1	42.0	9	0	1
	2-20-0	15	10	0.6	3.5	0	0	10
		25	10	1.8	10.5	2	1	7
		35	10	1.5	9.0	1	1	8
		75	10	2.7	16.0	3	1	6

DISCUSSION OF RESULTS

The averaged results reported herein indicate a remarkably good response to small applications of fertilizer on the summerfallow wheat crop. As might be expected, considerable variation in response as between individual farms was recorded. If comparisons were made between seasons, this variation was considerably enhanced. For instance, in 1939 the smallest increase was 5.6 bu. and the greatest 21.4 bu. for the 50# rate of 11-48-0 fertilizer. However, the smallest increase in the 5 years was recorded in 1941 (1.4 bu.) and the greatest in 1940 (25.0 bu.). As mentioned elsewhere, the dry season of 1941 gave relatively poor results. It might also be noted that out of 75 trials, there were only 9 cases in which the 50# rate of 11-48-0 failed to give significant increases and 5 of those were in 1941 (Table 3). The usual effects of phosphates were observed in respect to earlier maturity, better tillering and in more effective competition with weeds. The effect on maturity was somewhat erratic since in some fields the earliness would be pronounced (up to 10 days) while in others the difference would be slight, although the increase obtained might be quite as good. A similar situation seemed to prevail with regard to tillering. However, this and the matter of weed suppression was only incidentally observed throughout the period of these trials.

The best fertilizer on the average was 11-48-0 ammonium phosphate (Table 4). Triple superphosphate gave smaller increases at the same rates of P_2O_5 , this difference being somewhat more pronounced at the lower rates. The 2-20-0 showed the least effect but on the average the results were about proportional to the amount of P_2O_5 applied. At the lower rates of application, few plots showed significant increases in the case of the latter fertilizer, a result which might have been expected, considering the small amount of nutrients applied at these rates.

On the average, the greatest increases in yield were obtained from the highest rates of application. However, the commonly observed effect that the first increment of a nutrient will produce relatively greater increases

than subsequent ones, is evident in these data. The maximum possible increase obtainable was not established with the rates used in these trials.

Low rates are considered the safest and best in this relatively dry region because of the fear that higher rates would produce a growth too luxuriant for the limited moisture supply to sustain. The presently recommended rates of 11-48-0 are from 20 to 40 lb. per acre. It appears from these data that the higher rates would be advantageous especially in areas where moisture supplies are generally satisfactory, and on heavier soils with better moisture holding capacity. It should also be pointed out that higher rates are ultimately likely to become necessary as phosphorus becomes more deficient in the soil. Twenty lb. of 11-48-0 will hardly supply phosphorus for one good crop after summerfallowing while a common practice in the area of these tests is to grow at least two grain crops after fallowing, of which only the summerfallow crop is fertilized. At the lower rates, depletion of phosphorus will therefore continue, and the balance will have to be met eventually by using higher rates of application.

Table 4 illustrates the lessening advantage which 11-48-0 showed over triple superphosphate at the higher rates. At the lowest rate (15# of 11-48-0, 17# of 0-43-0) there was an advantage in yield of 2.1 bu. in favour of the 11-48-0. However, at the highest rate the advantage was only 1.1 bu. for the 11-48-0. Since the same amount of P_2O_5 was applied at each comparative rate of the two fertilizers, part of the advantage obtained from the 11-48-0 may be attributed to the nitrogen in the latter fertilizer. However, there is also the possibility that the nature of the carrier compound might have an influence on the availability of phosphorus to the plant. The matter of response to nitrogen is one being given further study in connection with the use of fertilizer in this area.

As shown in Table 3, the years 1939, 1940 and 1942 gave increases which were quite similar both in the bu. increase and the % increase over checks. The season of 1943 was rather dry but while the bushels per acre

TABLE 4.—AVERAGE INCREASE FOR ALL TRIALS AND COST OF FERTILIZER PER ACRE

Fertilizer	Approximate rate lb. per acre	Approximate cost per acre	Average increase bu. per acre, 1939-1943
		\$	
11-48-0	15	0.46	6.8
0-43-0	17	0.44	4.7
2-20-0	15	0.27	2.1
11-48-0	25	0.76	8.2
0-43-0	28	0.71	6.2
2-20-0	25	0.45	3.3
11-48-0	35	1.07	9.0
0-43-0	40	1.01	7.7
2-20-0	35	0.63	3.7
11-48-0	50	1.52	10.5
0-43-0	56	1.42	9.4
2-20-0	55	1.35	5.5

increase was less, the percentage increase remained about the same. The season of 1941, which was quite dry, showed a different result. Responses were not only less, but also more erratic in nature. Examination of Table 2 will show that the season of 1943 had no advantage over 1941 in June and July precipitation. However, the average temperatures in June and July of 1941 were definitely higher, and field notes regarding this season indicate that high temperatures occurred at the heading stage. As already indicated, the two seasons 1941 and 1943 were both rather dry, actually the average check plot yields were a little higher in 1941 (17.6 bu. per acre) than in 1943 (17.0 bu.). The difference in response in the two seasons is, however, very marked as may be seen by reference to Table 3. It is such erratic results which lead some to believe that phosphates pay as well in dry seasons as in moist, while others consider that the fertilizer has no value in a dry year. Actually, the response depends on the nature of the "dry" season. Probably the least advantage from the phosphate fertilizer is obtained when dry, hot weather occurs in the heading stage after a favourable start in spring. Cool, moist seasons appear to be favourable to the fertilized fields.

Throughout the 5 seasons of the tests, 23 trials were placed on dark brown soils, 48 on black and 4 on gray. The average increases on the dark brown and the black soils were very similar and practically the same as the over-all average shown in Table 4. It might be noted that the tests on dark brown soils were located in a part of the zone lying adjacent to the more moist black soils (Figure 1) and this may be a factor in the comparatively good results obtained on the dark brown soils. It has generally been considered that increases from fertilizer would be less on the dark brown soils than on black soils where moisture conditions were uniformly better and temperatures lower. Further experiments would be required to definitely establish that greater responses are obtainable on the black soils, but there is a definite likelihood that responses would be less erratic due to the more favourable climatic conditions of the latter zone. Only four sets of plots were located on gray soils (podzolic). The % increases tended to be a little higher on these soils, although bu. per acre increases were no higher. However, the number of plots was too small to warrant definite conclusion. Further experiments are in progress concerning fertilization of the gray soils.

As previously mentioned, among the black soils of the area there are two distinct separations which may be made and which could have significance regarding the response to phosphatic fertilizers: the high lime (rendzina-like) soils, and the non-limy normal types. However, after examining the data there appears to be only a slight difference in response on high lime soils (22 tests) compared to normal lime free soils (26 tests). The responses are slightly better on the lime free soils especially at the higher rates. For instance, the 50# application of 11-48-0 gave 10.5 bu. average increase on high lime soils, and 11.1 bu. on lime free, while the corresponding rate of 0-43-0 gave 8.7 and 9.8 bu. increase, respectively.

The statement commonly appears that sandy soils give poor responses to phosphatic fertilizers while clay soils are highly responsive. In order to see if these data gave any indication of a general trend in this connection, Table 5 was compiled. The light textured soils were fine sandy loams, and

TABLE 5.—INCREASES OBTAINED ON LIGHT, MEDIUM AND HEAVY TEXTURED SOILS

	Rates			
	1	2	3	4
11-48-0				
Light textures	6.9	7.0	9.1	10.9
Medium textures	6.3	8.4	8.5	10.6
Heavy textures	7.7	10.4	11.4	12.0
0-43-0				
Light textures	2.9	4.9	5.4	6.9
Medium textures	5.3	6.5	8.1	10.1
Heavy textures	5.8	8.5	10.1	9.8

light loams. The heavy soils were clays and silty clay loams. In all there were 10 trials on light textured soils and 11 on heavy soils. The data in Table 5 indicate a general tendency for better response to phosphates on heavy soils than on light. This result may in part be attributed to the better moisture retention found in the heavy soils. The most marked effect is, however, the difference in response between 11-48-0 and 0-43-0 on light soils. The former is a much more efficient fertilizer than the latter for the light soils. The difference in response is much greater than that shown on the medium soils, although the heavy textured soils appear to stand intermediate in this regard. The difference in response as between 11-48-0 and 0-43-0 on light textured soils might be readily attributed to nitrogen added with the former fertilizer. As suggested by Ellis (2), light soils which have suffered from wind erosion are especially likely to benefit from additional nitrogen and undoubtedly some erosion had occurred on these soils. The better response obtained from 11-48-0 on the heavier soils may be, in part, due to the more available form of the phosphate in the ammonium phosphate, as compared to triple superphosphate, as has already been suggested. Evidence of a deficiency of available nitrogen in light textured soils after some years under cultivation has been observed, but the heavier soils appear to be always well supplied with nitrates. In this connection it should be pointed out once again that all trials were on summerfallow land which should normally have a good reserve of nitrates. In a relatively dry climate such as prevails in this region, no important loss of nitrates can occur through leaching, except on light textured soils. It is therefore difficult to account for the difference in response on medium and heavy textured soils, as between these fertilizers simply on the basis of difference in nitrogen content.

As stated above, increased tillering, somewhat darker green colours, and a generally stronger growth were commonly observed in the treated plots. However, it was only in a few cases that striking symptoms of phosphate deficiency were observed in check plots, and these only where very high increases in yield were obtained. A field near Watrous, Saskatchewan, showed the most pronounced evidence of phosphate deficiency of any observed. The untreated plants were of an unhealthy greyish blue-green colour, as if beginning to suffer from drouth, although moisture was

plentiful. Stooling was poor, the growth relatively poor and the crop was later than the treated plots by at least 10 days. In comparison with the treated plots immediately adjacent, the differences in colour, vigour and stage of maturity were most striking. The 50 lb. application of 11-48-0 gave 23 bu. increase in this field, other treatments giving corresponding increases. In general, it would appear that easily observable symptoms of phosphate deficiency in grain are not commonly encountered in this area except where direct comparisons between the growth and tillering on treated and untreated plots can be made.

Determinations of protein content and of bu. wt. were made on selected samples in each season.¹ The protein content showed no relationship to fertilizer treatment. The treated plots tended to average higher in bu. wt. but the difference was slight. The most important fact found in connection with the determination of bu. wt. was that the results were no different in the "dry" year of 1941 than in the "wet" year of 1942. The common impression that grades of wheat tend to be lower on fertilized crops in dry years, was not substantiated by these data.

SUMMARY

Results of fertilizer trials over a wide range of soils in a portion of Saskatchewan are given. The fertilizers used were of three kinds: 11-48-0, 0-43-0, and 2-20-0. They were applied at 4 rates, the rates being such that direct comparison of efficacy of P_2O_5 applied in 11-48-0 and in 0-43-0 might be made. Results showed that the 11-48-0 fertilizer gave larger increases than were obtained when the same amount of P_2O_5 was applied in 0-43-0. This difference may not be altogether attributable to the nitrogen carried in the former fertilizer. Good increases were obtained at the lowest rate of application, but greater increases resulted from the highest rate used (50# 11-48-0 or equivalent of 0-43-0). At the higher rates 0-43-0 gave comparatively better results than at the lower, and the advantage of the 11-48-0 fertilizer was therefore lessened. On lighter soils the 11-48-0 showed a more favourable response in comparison to the 0-43-0 than on medium or heavy soils. Heavy soils showed the greatest response to phosphates especially from the use of 11-48-0. The results from 2-20-0 were about proportional to the amount of phosphorus applied. The data revealed no distinct difference in response as between the dark brown and black soils, nor between calcareous and non-calcareous soils. The tendency is towards better responses in cool moist seasons, and poorer in dry, hot ones. No definite effect appeared on protein content, or in bu. wt., due to fertilization.

ACKNOWLEDGMENTS

Acknowledgment is made to the efficient services of the late F/Lt. R. A. Holtby, R.C.A.F., who did much of the work in connection with these tests in the earlier years. Acknowledgment is also due the field staff of the Fertilizer Division of the Consolidated Mining and Smelting Co. for generous assistance, and to colleagues of the Department of Soils, University

¹ These results are reported by courtesy of Dr. R. K. Larmour, Department of Chemistry, University of Saskatchewan, under whose direction the determinations were made.

of Saskatchewan. The co-operation of the many farmers who willingly gave time, equipment and the use of their land in the carrying out of these experiments is gratefully acknowledged. This investigation was supported by funds granted through the Saskatchewan Research Foundation.

REFERENCES

1. BEAR, F. E. Soils and Fertilizers. P. 274. John Wiley & Sons, Inc. 1942.
2. ELLIS, J. H. Fertilization of Dry Soils in Canada. Le Congres International des Engrais Chimiques, Rome. 3-6 Octobre. 1938.
3. GODEL, G. L. Cereal Growing on Weedy Lands in North Eastern Sask. Sci. Agr. 19 : 21-32. 1939.
4. MITCHELL, J., H. C. MOSS and J. S. CLAYTON. Soil Survey Report No. 12. College of Agriculture, University of Saskatchewan, Saskatoon, Saskatchewan. 1944.
5. MITCHELL, J. A preliminary Investigation on Determining the "Available" Phosphorus in Saskatchewan soils. Sci. Agr. 12 : 346-351. 1932.
6. REPORT ON CO-OPERATIVE EXPERIMENTS WITH FERTILIZERS. Publications Branch, Department of Agriculture, Regina. 1930.
7. REPORT OF INVESTIGATIONS. P. 24. Soil Res. Lab. Dom. Expt. Sta., Swift Current, Sask. 1943.
8. REPORTS OF FERTILIZER EXPERIMENTS ON WHEAT. (Mimeographed), Department of Soils, Univ. of Sask., 1939-1942.
9. RUSSELL, E. J. Artificial Fertilizers in Modern Agriculture. Min. of Agric. and Fisheries, London, Eng. Bull No. 28 : 85-87. 1931.
10. RUSSELL, R. C. and B. J. SALLANS. The Effect of Phosphatic Fertilizers on Common Root Rot. Sci. Agr. 21 : 44-51. 1940.
11. SOILS AND MEN. Yearbook of Agriculture, U.S.D.A. P. 381. 1938.
12. TRUOG, E. The Determination of Readily Available Phosphorus of Soils. Jour. Amer. Soc. Agron. 22 : 874-882. 1930.
13. UNPUBLISHED DATA, SOILS DEPT., UNIV. OF SASK., SASKATOON, SASK.
14. VANTERPOOL, T. C. Present Knowledge of Browning Root Rot with Special Reference to its Control. Sci. Agr. 20 : 735-749. 1940.

BLENDING VALUE OF CANADIAN WHEAT¹

T. R. AITKEN², M. H. FISHER³ AND J. A. ANDERSON⁴

Grain Research Laboratory, Board of Grain Commissioners for Canada, Winnipeg, Manitoba

[Received for publication August 26, 1946]

The improvements in soft wheat flour obtained by adding hard Canadian wheat to the mill mix are principally that the flour absorbs more water, that the dough tolerates wider variations in mixing and fermentation time, and that the loaf is larger, lighter, and of better texture. In 1933, Birchard and Aitken (2) showed with a number of European and other soft wheats that the improvements obtained in the blend were directly proportional to the amount of Canadian wheat that was added. It has also been shown (Aitken and Geddes, 1) that the blending value of Canadian wheat is directly related to its protein content. But the literature does not appear to contain a comprehensive set of data for representative commercial samples of Canadian wheat with which quantitative comparisons of blending value can be made with respect to both the percentage of Canadian wheat used and its protein content. Such data are presented in Part I of this paper.

Because of war difficulties and the present scarcity of wheat, most countries are now milling a larger percentage of the wheat kernel into flour. Whereas extraction rates of 70 to 74% were customary before the war, rates of 80 to 90%, or even higher, are now mandatory in many countries. Lengthening the extraction yields flours of progressively poorer baking quality and colour, but of increasing nutritive value provided that the extraction is not raised too far. Since long extraction flours will be widely used for the next year or two, and may be adopted permanently in some countries, it is pertinent to study the blending value of Canadian flour at different extraction levels. This subject is considered in Part II of this paper. Judged by traditional methods, increasing the extraction reduces the blending value.

I. BLENDING VALUE OF CANADIAN WHEAT OF DIFFERENT PROTEIN CONTENTS

MATERIALS AND METHODS

The basic wheat used for blending with the Canadian wheat was a composite sample containing 40% of English wheat, 30% of Australian, and 30% of Argentine. This triple mix had a protein content of 10.5%. It is representative of the mix with which Canadian wheat is blended in the United Kingdom when world wheats are in good supply.

Composite samples of Canadian wheat were prepared from individual samples of grades 1, 2, and 3 Manitoba Northern taken from more than 4,000 carlots of wheat inspected in Western Canada during the 1943-44 crop year. Protein determinations were made on the individual samples and these were subsequently grouped and composited within narrow protein ranges to give 4 composite samples. The protein contents of these and

¹ Paper No. 83 of the Grain Research Laboratory, Board of Grain Commissioners for Canada, Winnipeg, Manitoba, and Paper No. 247 of the Associate Committee on Grain Research.

² Chemist.

³ Technician.

⁴ Chief Chemist.

the number of individual samples represented in each were as follows: 14.4%, 579 samples; 13.1%, 2,367 samples; 12.0%, 1,197 samples; 10.4%, 152 samples. A fifth composite with a protein content of 10.0% was obtained by compositing 6 samples of low protein wheat grown on the grey wooded soils of northern Alberta.

The 3 foreign and the 5 Canadian wheats were milled to yield (about 70% extraction) in a laboratory mill, and the 3 foreign flours were then blended in the proportions already mentioned. For the sake of simplicity this blended flour is referred to as the Triple Mix. The flours had the following protein contents: Triple Mix, 9.4%, Canadian Flours, 13.9, 12.6, 11.2, 9.9, and 9.4%.

Triplicate loaves were baked by the malt-phosphate-bromate procedure (Geddes, *et al.*, 3) from the Triple Mix and from each Canadian flour, and also from the Triple Mix in blends with 25, 40, 55, 70 and 85% of each Canadian flour. The loaves were measured for volume and scored for appearance, crumb colour, and crumb texture. Absorptions were predetermined with the aid of the Farinograph, and any adjustments found necessary were made at the time of mixing. Special attention was paid to the handling properties of the dough during fermentation and at the time of panning. The data reported are mean values for the triplicate bakings.

RESULTS AND DISCUSSION

The relation between loaf volume and the amount of Canadian wheat in the blends is illustrated graphically in Figure 1. One curve is shown for each of the 5 Canadian wheats, and labels give the protein contents of these wheats.

The curves show that the Canadian wheat of highest protein content (top curve) is most effective in increasing the loaf volume of the blend, and that a straight-line relation exists between loaf volume and the percentage of Canadian wheat in the blend. With Canadian wheat of 13.1% protein, the rate of increase in loaf volume is also substantial, and even with Canadian wheat of 12.0% protein a definite improvement is obtained. But when the protein content of the Canadian wheat drops to 10.4%, the increase in loaf volume is negligible, even with percentages of 80% and higher in the blend; and with Canadian wheat of 10.0% protein there is a decrease rather than an increase in loaf volume. On the basis of equal parts of the Triple Mix and Canadian, which is a suitable proportioning for comparisons, the loaf volume changes from the highest to the lowest protein Canadian wheats are: + 23, + 15, + 10, + 3, and - 5%, respectively. In the blends containing the lowest protein Canadian wheat there is a sharp drop in loaf volume with the first addition (25%), but further additions cause no further reduction. Thus the baking strength of this Canadian wheat of 10.0% protein is actually lower than that of the Triple Mix even though the protein contents are much the same. Similarly, the baking strength of the 10.4% Canadian wheat is only slightly better than the Triple Mix. It is therefore apparent that Canadian wheat can be so low in protein content that it is quite unsuitable for supporting a blend like the Triple Mix.

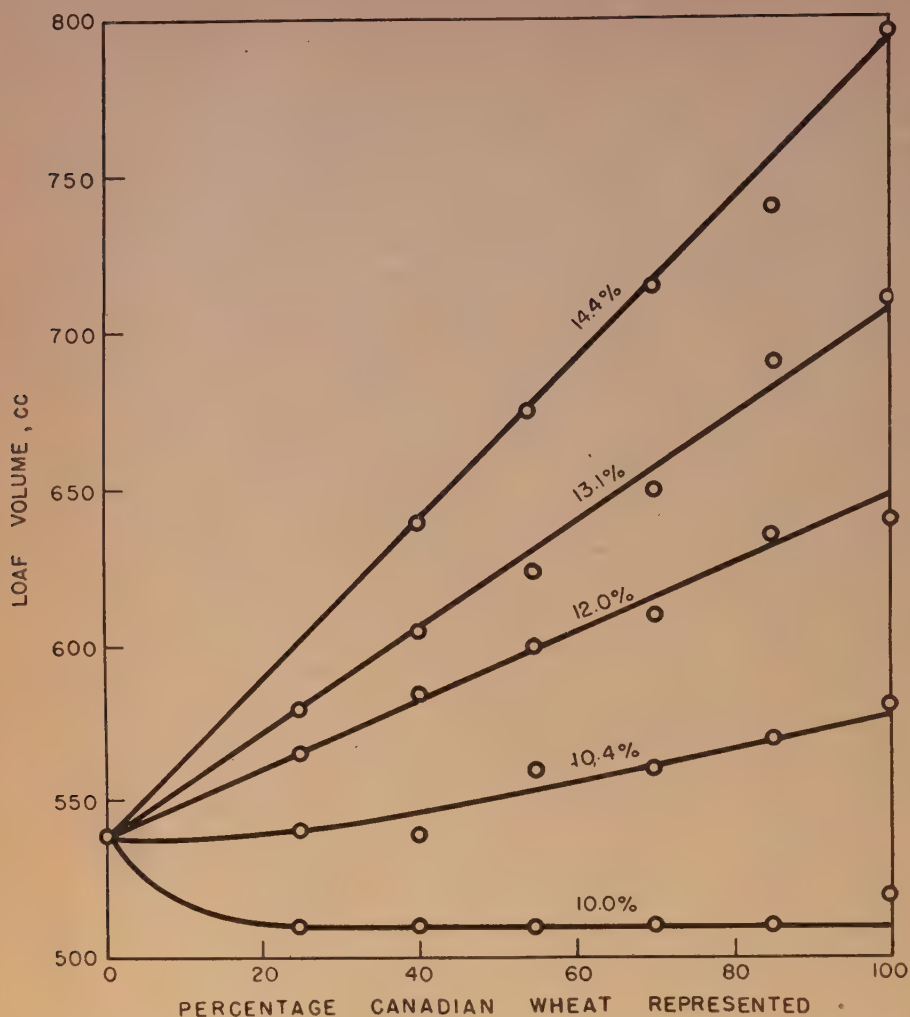


FIGURE 1. Graph showing relation between loaf volume and amount of Canadian wheat in the blends. Labels indicate the protein contents of the Canadian wheats.

When one considers that additions of Canadian wheat to weaker wheats bring about improvements other than increased loaf volume, it is possible that wheat of 12% protein might be satisfactory in mixtures for the milling of certain types of flour. But the data show that at least 80% of wheat of 12.0% protein would be required to give a loaf of the same volume (625 cc.) as 50% of wheat of 13.1% protein or 35% of wheat of 14.4% protein.

A photograph showing the loaves made from the Triple Mix alone, and from the blends containing 55% of each of the five Canadian wheats appears as Figure 2. Considerable differences are readily apparent in the volumes of these loaves.

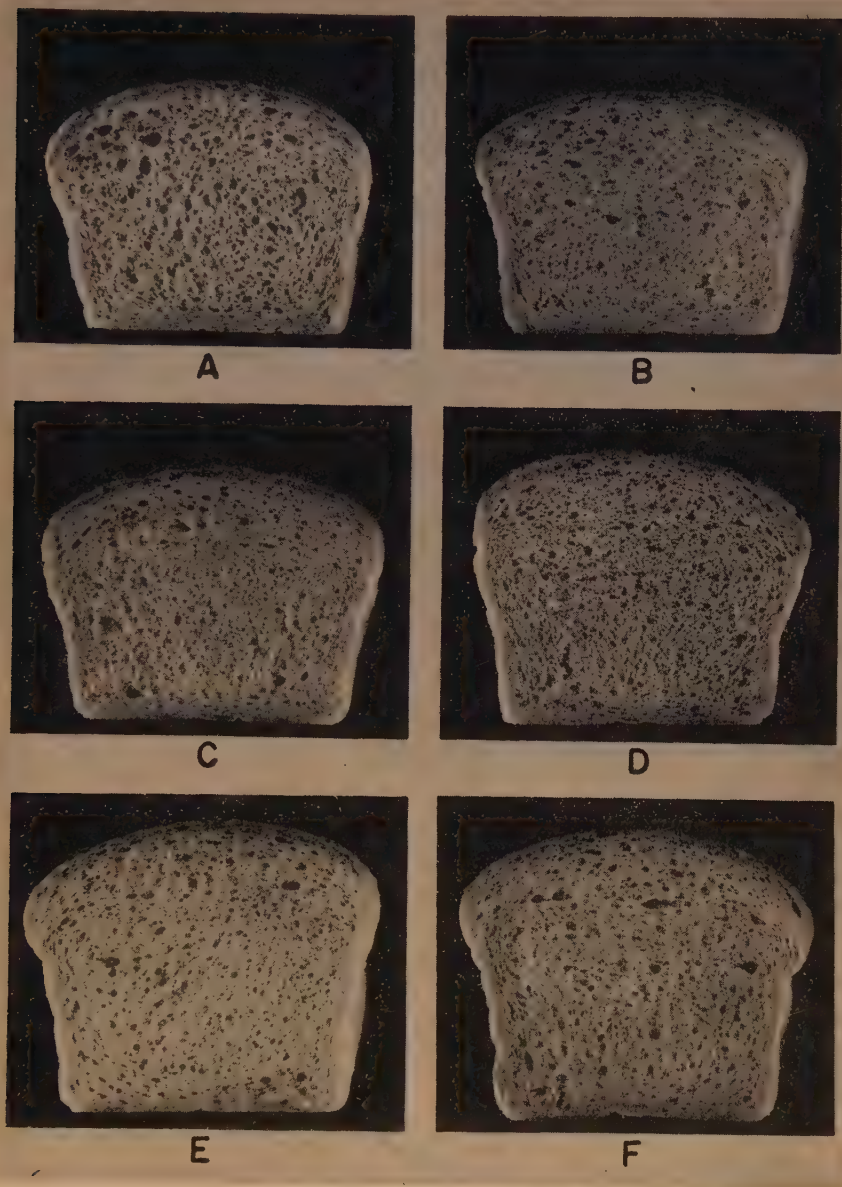


FIGURE 2. Photograph of loaves made from the Triple Mix (A) and from blends containing 55% of each of the five Canadian wheats: 10% protein (B), 10.4% protein (C), 12.0% protein (D), 13.1% protein (E), 14.4% protein (F).

The effects on protein content, absorption, crumb texture and crumb colour of increasing additions of the Canadian wheats to the Triple Mix are shown by the four graphs in Figure 3. All four graphs show essentially the same thing for each quality; viz., that the improvement obtained is directly related to the initial protein content and amount of Canadian wheat in the blend.

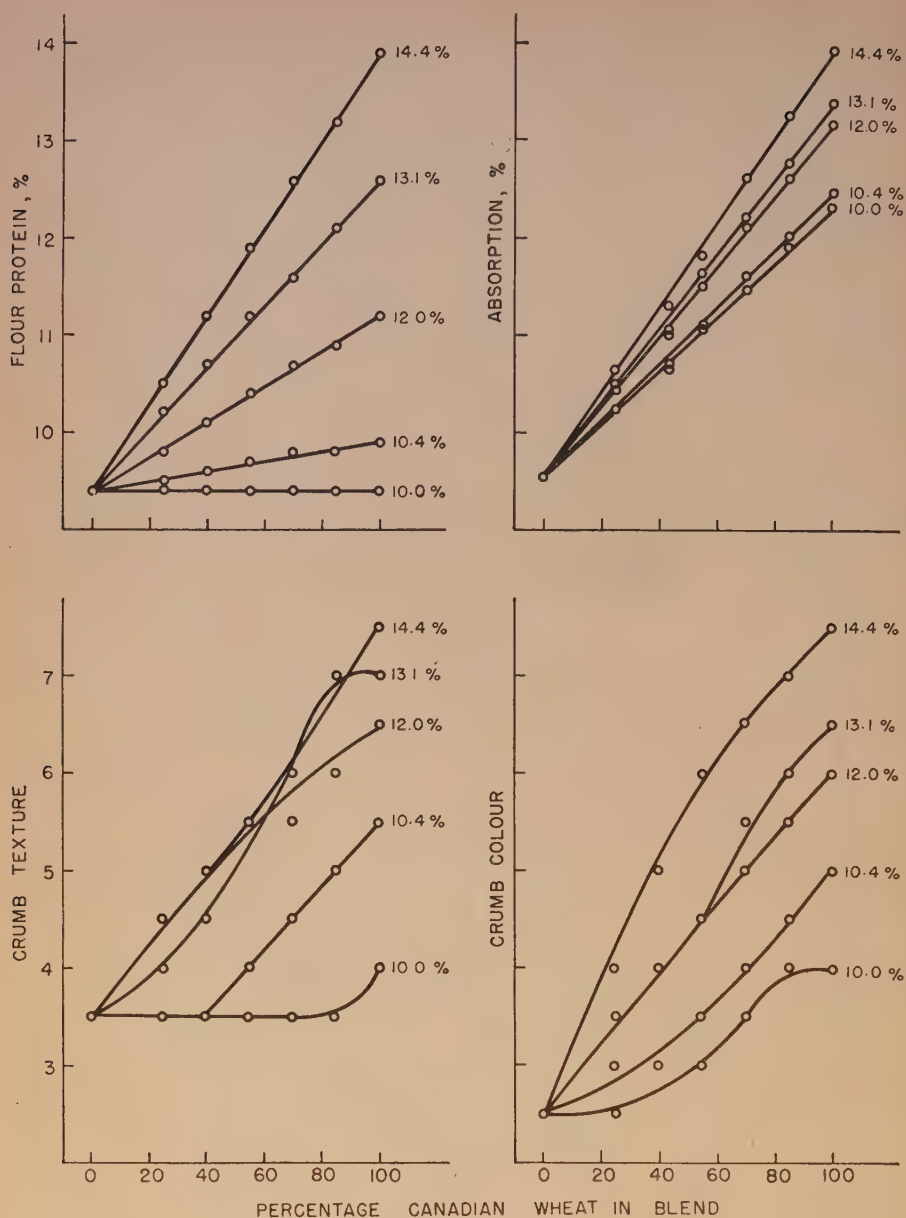


FIGURE 3. Graphs showing relation between flour protein, absorption, crumb texture, crumb colour and amount of Canadian wheat in the blends. Labels indicate the protein contents of the Canadian wheats.

The pattern of the curves for protein content bears a striking resemblance to that for loaf volume (Figure 1) except that the protein content of the blend containing the lowest protein Canadian wheat (10%) is the same for all concentrations. This would suggest that the quality of the protein of this Canadian wheat is inferior to that of the Triple Mix,

otherwise a drop in loaf volume of the latter would not have occurred when the Canadian wheat was added. The steady increase in absorption resulting from increasing additions of the Canadian wheats is of particular importance to the commercial baker, for this means that his yield of bread per unit weight of flour will also increase. This increase is obtained with the low protein as well as with the high protein Canadian wheats; for the differences in absorption among the blends are not particularly large until more than about 50% Canadian is used. In each blend improvement in crumb colour occurred with each addition of Canadian wheat and the higher the protein content the better the colour score. In the blends containing the 10.4% protein Canadian wheat, no improvement in texture occurred until 40% was present; and in the blends containing the 10% protein sample, the texture score was the same for all concentrations up to 85%. Improvement in texture was, however, quite noticeable in the blends containing the 3 other Canadian wheats, but the differences were relatively small at most concentrations.

The handling quality of the dough was greatly improved in the blends containing the Canadian wheats of 12% protein and higher, and with each addition the doughs became more lively, more springy, and more stable. But the higher the initial protein of the Canadian wheat the better was the improvement. In the blends containing the 10.4% Canadian wheat, improvement was not detected until more than 40% was added; and in the blends containing the 10% protein sample, the doughs were essentially the same—short and tender.

It is apparent from these results that the blending value of Canadian wheat, as reflected by all-round improvement in dough and loaf quality, is closely related to the initial protein content and the amount used. During the past 18 years, the protein content of Western Canadian wheat has averaged 13.6%. At this level the baking strength, of a blend of soft wheat, such as that used in these studies, will be improved by about 20% by the addition of an equal weight of Canadian wheat. A greater improvement would be expected if the soft wheat was all English, and a lesser improvement if it contained a high percentage of filter wheat such as Argentine. However, the improvement of the final blend is still more dependent on the quality of the Canadian wheat which is in turn related to its protein content. The importance of avoiding wide variations in the protein content of export shipments of Canadian wheat is thus apparent.

II. BLENDING VALUE OF CANADIAN FLOUR OF DIFFERENT EXTRACTION

In many of the countries that import Canadian flour for blending purposes, the extraction of home-milled flour for bread-making is controlled by Government regulation. This was introduced during the war and is maintained because of the extreme shortage of wheat. In Great Britain the extraction was raised to 73% in 1939 from an uncontrolled pre-war level of about 70%. In 1941 it was increased to 75% and in 1942 it was increased to 85%. It remained at this level until 1945 when it was reduced to 82.5% and later to 80%. This extraction rate was in effect for only a few months; in 1946 it was increased in two short steps to 85% and 90%. The 90% extraction is expected to be only a temporary measure and will doubtless be lowered as soon as the world wheat situation improves. Whether the

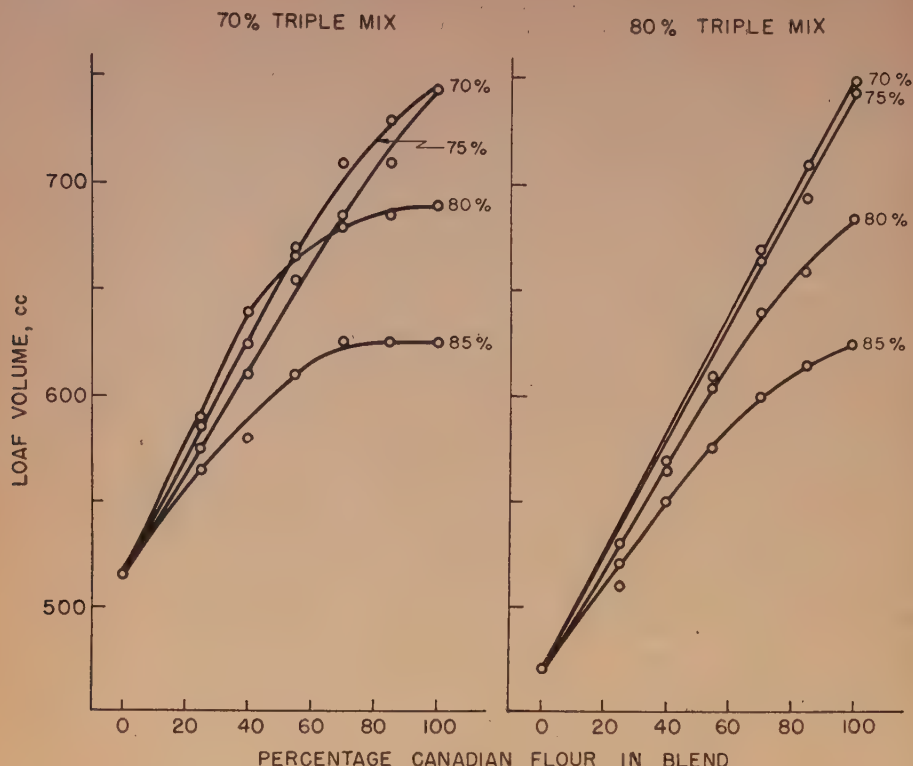


FIGURE 4. Graphs showing relation between loaf volume and amount of Canadian flour in the blends. Labels indicate extractions of Canadian flours. Left-hand group is for the blends with the 70% Triple Mix; right-hand group is for the blends with the 80% Triple Mix.

restrictions on flour extraction will be removed entirely or will be maintained at 80% or higher has not yet been decided. It therefore seemed advisable to obtain information on the value of Canadian flour of different extraction for blending with weaker flours of different extraction.

MATERIALS AND METHODS

The same Triple Mix was used as in the former study, but instead of milling each wheat to yield it was milled to provide 2 flours of 70 and 80% extraction. The corresponding flours were then mixed in proportions of 40% English, 30% Australian and 30% Argentine. Ash contents were 0.57 and 0.60%.

Four Canadian flours of 70, 75, 80 and 85% extraction were used for the blending. Ash contents were 0.49, 0.54, 0.72, and 0.92%. They were milled from a wheat mix composed of equal parts 1 and 2 Northern (protein 13.3%) representing a number of cargoes of each grade shipped from Fort William in the summer of 1945. The flour extractions were chosen to provide two samples of the same extraction as the Triple Mix flours, one of intermediate extraction that corresponds to flour milled in Great Britain in the early years of the war, and one of long extraction that corresponds to flour milled during most of the war years and until quite recently. It was not possible to duplicate the dress and fineness of long

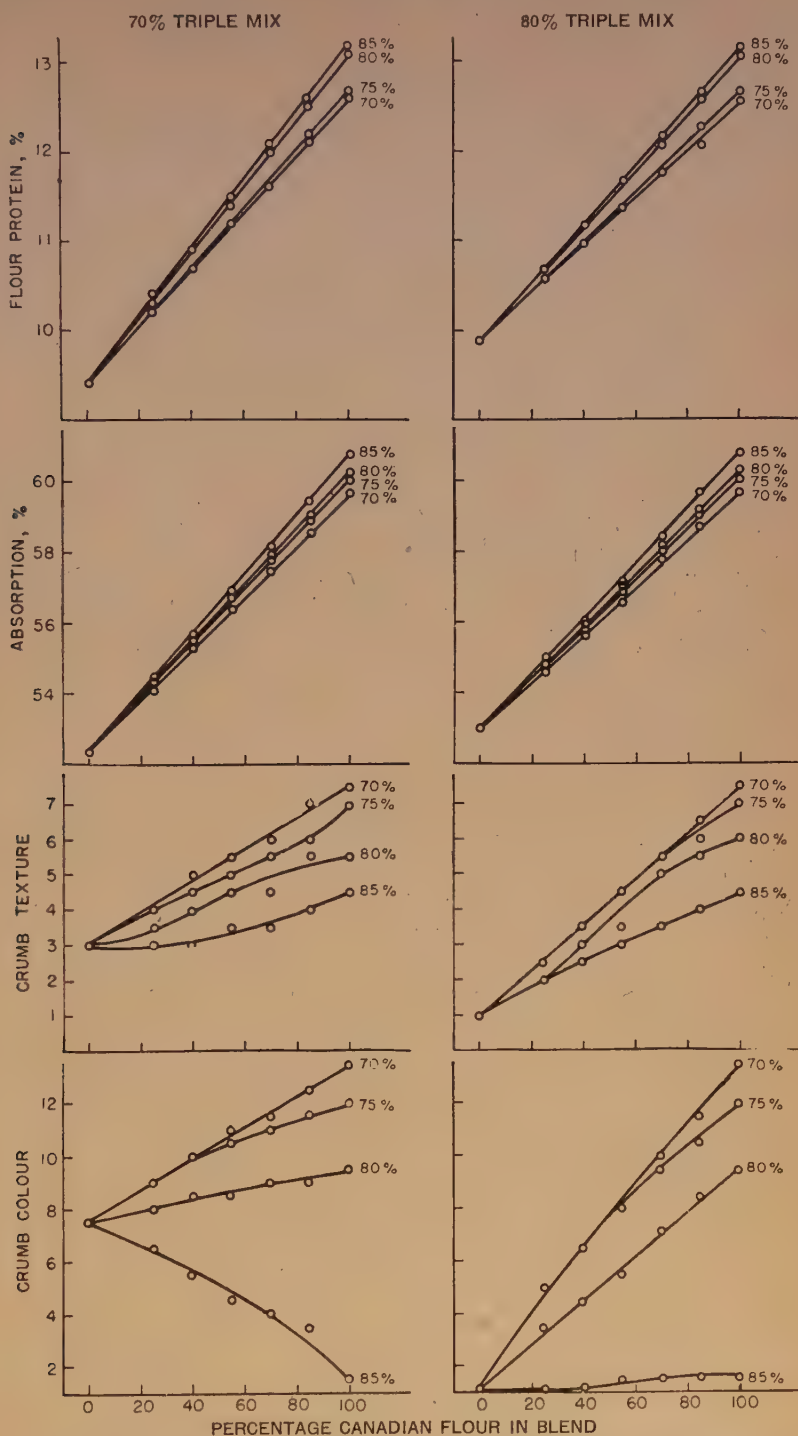


FIGURE 5. Graphs showing relation between protein content, absorption, crumb texture, crumb colour and amount of Canadian flour in the blends. Labels indicate extractions of Canadian flours. Left-hand group is for the blends with the 70% Triple Mix; right-hand group is for the blends with the 80% Triple Mix.

extraction flours now milled commercially, and it is questionable if this can be done in a laboratory mill. The increased yields were obtained by additional reduction of the fine shorts, coarse shorts, and feed flour, and for the 85% extraction by a more thorough cleaning of the bran.

The Canadian and Triple Mix flours were blended in the same proportions as in the former study and the flours were baked by the same baking method. Because of the wide range in crumb colour encountered, the range for scoring had to be widened, otherwise many of the loaves would have had negative scores. Thus a score of 7 generally awarded bread made from 1 Northern flour was increased to 13.5. This was the only change made in the scoring procedure.

RESULTS AND DISCUSSION

The relation between loaf volume and composition of the blends is shown by the two graphs in Figure 4. The left-hand group contains 4 curves showing the effects of adding Canadian flour of 70, 75, 80 and 85% extraction to a Triple Mix of 70% extraction; corresponding curves for the Triple Mix of 80% extraction are shown on the right.

In the blends with the 70% Triple Mix (left) the increase in loaf volume is much the same for each addition of the 70 and 75% Canadian flours at all concentrations, and also for the 80% Canadian flour up to a concentration of about 55%. With the 85% Canadian flour, loaf volume is lowest at all concentrations. With both the 80 and 85% Canadian flour, additions higher than 55% were of little value; after this level, loaf volume changed little or not at all. Thus for increasing the baking strength of the 70% Triple Mix, Canadian flours of 70, 75 and 80% extraction are about equal in concentrations up to about 55%. In higher concentrations the 70 and 75% flours are about equal in value, both flours are better than the 80% flour, and all these 3 flours are better than the 85% flour. The same relations among the blends occur with the 80% Triple Mix (right) but at all levels of fortification loaf volumes are lower.

The effect on protein content, absorption, crumb texture, and crumb colour, of increasing additions of the Canadian flours to the two basic flours, is shown by the eight graphs in Figure 5. The graphs at the left are for the blends with the 70% Triple Mix; those at the right are for the blends with the 80% Triple Mix.

In both series of blends, protein content increases with each addition of each Canadian flour. Although the protein levels increase with flour extraction this is not always reflected by higher baking strength. This is due to the increasing percentage of low grade flour in the long extraction flour, and the fact that the low grade material is high in protein content but low in baking strength. In absorption, the same upward trends are found as for protein content, but the differences between corresponding blends are somewhat smaller. Thus for increasing the absorption of the Triple Mix flours, the 4 Canadian flours are about equal in value. Since, however, it is known that dough from long extraction flour loses more water during the baking procedure than dough from short extraction flour, the higher initial absorption of the former would be of little real advantage because a higher scaling weight would be required to give a loaf of the same weight.

Crumb texture improved in both series of samples with each addition of Canadian flour, and the lower the extraction the greater the improvement. The scores for the blends with the 70% Triple Mix were, in general, higher than those with the 80% Triple Mix, but the differences narrowed appreciably in the higher concentrations of Canadian flour. Crumb colour also improved in both series of samples with each addition of the 70, 75 and 80% Canadian flours and, again, the lower the extraction the greater the improvement. This was not so, however, in the blends containing the 85% Canadian flour; for with the 70% Triple Mix crumb colour became progressively poorer, and with the 80% Triple Mix it was essentially the same at all concentrations.

The doughs for the blends with the 70% Triple Mix improved in liveliness, spring, and stability, with each addition of the 70 and 75% Canadian flour, and differences were negligible between corresponding samples. With the 80% Canadian flour, improvement was not detected until 70% and higher was used, and none of the doughs equalled those containing the shorter extraction flours. No apparent improvement in dough handling quality resulted from additions of the 85% Canadian flour, and at concentrations higher than 25% the doughs were soft and tender. In the blends with the 80% Triple Mix, the same trends were found, but, blend for blend, the doughs were inferior in all-round handling quality.

The results of this investigation show that the blending value of Canadian flour is directly related to its extraction, the amount used, and the extraction of the weaker flour with which it is blended. Moran and Jones (4) state that British-grown wheat is relatively poor in baking quality and generally unsuitable for the milling of flour for bread-making, except when blended with at least an equal amount of strong imported wheat of which Canadian is the unexcelled example. It therefore seems reasonable to compare the blending value of the Canadian flours of different extraction when mixed in the 50 : 50 proportions. It will also be noted that Figure 4 shows that the curves for loaf volume are essentially linear for all the Canadian flours up to about this concentration. The baking data for the several Canadian flours in blends with equal parts of each Triple Mix flour are given in the following table:

Triple Mix (50%)	Canadian (50%)	Absorption	Loaf volume, cc.	Increase	Crumb texture	Crumb colour
Extraction	Extraction					
%	%	%		%		
70	70	56.0	640	24	5.2	10.6
	75	56.2	655	27	4.9	10.3
	80	56.3	660	28	4.3	8.7
	85	56.5	600	17	3.3	5.3
80	70	56.3	610	30	4.2	7.7
	75	56.6	610	30	4.2	7.7
	80	56.7	600	28	3.4	5.3
	85	56.9	570	21	2.8	1.2

In the blends with the 70% Triple Mix, the loaf volumes for the 70, 75 and 80% Canadian flours are essentially the same and distinctly higher than that for the 85% Canadian flour. Although there is a downward trend in both crumb texture and crumb colour with increasing flour extraction, the differences between the 70 and 75% Canadian flours are so small that they can be disregarded. There is, however, a distinct drop in both scores for the 80 and 85% flours, particularly the latter. Dough handling quality was quite satisfactory and about the same for the two lower extraction flours, but less satisfactory for the 80% flour and much inferior for the 85% flour. Thus, for improving the all-round baking quality of the weaker flour, there is little to choose between 70 and 75% Canadian flours at this concentration. For improving baking strength only, the 80% Canadian flour would be equally as satisfactory but for other loaf and dough qualities it would be less desirable. Although the longest extraction Canadian flour increased baking strength considerably, it is the least desirable of all the flours. Essentially the same conclusions can be drawn for the blends with the weaker flour of 80% extraction, but, blend for blend, dough and loaf qualities are distinctly inferior. However, the percentage increases in loaf volume are generally slightly higher, blend for blend; thus, relatively, the Canadian flours improved the baking strength of the longer extraction Triple Mix equally as well as they did the shorter extraction Triple Mix.

In the Report of the Conference on the (British) Post-war Loaf (5), it was unanimously recommended that National Flour of 80% extraction should be maintained for the time being, and the feasibility of importing only flour of similar extraction was also considered. It is therefore of interest to compare the baking quality of the 70% extraction Canadian and Triple Mix flours with that of the 80% extraction Canadian and Triple Mix flours using a blend of equal parts of each flour for the comparison. The data show that, while absorption is essentially the same, baking strength, crumb texture, crumb colour and dough handling quality are distinctly better for the shorter extraction blend. Improvement in baking strength (loaf volume increase of the weaker flour) is, however, somewhat greater for the higher extraction blend. If the future trend in milling is toward long extraction (about 80%), the most noticeable effect on baking quality will be inferior dough handling quality and less pleasing internal loaf characteristics.

SUMMARY

This paper is presented in two sections dealing respectively with the blending value of Canadian wheats of different protein content and of Canadian flours of different extraction. In the wheat study, increasing amounts (25, 40, 55, 70 and 85%) of 5 Canadian wheats, having protein contents of 10.0, 10.4, 12.0, 13.1 and 14.4%, were added to a "weaker" blend (10.5% protein) composed of English (40%), Australian (30%), and Argentine (30%) wheats.

The blending value of Canadian wheat, as reflected by all-round improvement in dough and loaf quality, is directly related to the initial protein content and to the amount used. The results of this study indicate that Canadian wheat of 12% protein content is not suitable for giving adequate support to weaker wheat, and to obtain the best results, wheat of

higher protein is required. A protein content of around 13% would be a satisfactory minimum; for an addition of 50 to 60% gave a fairly large loaf with reasonably good internal characteristics and dough of satisfactory handling quality. Similar levels of quality were obtained with about 30 to 40% of wheat of 14.4% protein.

In the flour extraction study, the same increasing amounts of 4 Canadian flours of 70, 75, 80 and 85% extraction, milled from wheat of 13.3% protein, were added to flours of 70 and 80% extraction, milled from the weaker blend described above. The blending value of Canadian flour is directly related to its extraction, the amount used, and the extraction of the weaker flour with which it is mixed. For improving the all-round baking quality of a weaker flour of 70% extraction, there is little to choose between Canadian flours of 70 and 75% extraction; for improving baking strength only, flour of 80% extraction would be equally as satisfactory up to a concentration of about 55%. Although Canadian flour of 85% extraction increases baking strength considerably, it is the least desirable of the several flours investigated. Essentially the same conclusions apply for corresponding blends containing weaker flour of 80% extraction but, blend for blend, dough and loaf qualities are distinctly inferior. As indicated by the percentage increase in loaf volume, the Canadian flours improved the baking strength of the longer extraction flour equally as well as they improved the shorter extraction flour. If the trend in milling is toward longer extraction, the most noticeable effect on baking quality will be inferior dough handling quality and less pleasing loaf characteristics.

REFERENCES

1. AITKEN, T. R. and W. F. GEDDES. The behaviour of strong flours of widely varying protein content when subjected to normal and severe baking procedures. *Cereal Chem.* 11 : 487-504. 1934.
2. BIRCHARD, F. J. and T. R. AITKEN. Some characteristics of Canadian hard red spring wheat with special reference to its value for blending. *Proceedings of the World's Grain Exhibition and Conference, Canada, Vol. II*, 386-399. 1933.
3. GEDDES, W. F., T. R. AITKEN and M. H. FISHER. The relation between the normal farinogram and the baking strength of Western Canadian wheat. *Cereal Chem.* 17 : 528-551. 1940.
4. MORAN, T. and C. R. JONES. Nutrients in British-grown and imported wheat. *Milling*, 106, No. 22 : 470-473. 1946.
5. REPORT OF THE CONFERENCE ON THE POST-WAR LOAF. Ministry of Food. His Majesty's Stationery Office, London, England. 1945.

THE INFLUENCE OF SPRAY PROGRAMS ON THE FAUNA OF APPLE ORCHARDS IN NOVA SCOTIA: I. AN ' APPRAISAL OF THE PROBLEM AND A METHOD OF APPROACH¹

A. D. PICKETT, N. A. PATTERSON, H. T. STULTZ AND F. T. LORD²

Dominion Entomological Laboratory, Annapolis Royal, N.S.

[Received for publication August 30, 1946]

INTRODUCTION

In Nova Scotia, as elsewhere, the economical control of apple orchard insects is becoming progressively more difficult. During the early part of this century, fruit of good quality was produced with 2 or 3 applications of spray applied with hand-operated pumps. To-day, with greatly improved equipment and spray chemicals, 6 to 10 applications are required to produce crops reasonably free of insect damage. For the most part, the species of insects now creating the major control problems were of minor importance in the earlier days. An understanding of the bases of these phenomena now challenges the research ability of economic entomologists.

Kelsall (7) has recorded the general trend in the development of orchard sprays in Nova Scotia during the 30-year period beginning in 1908. Briefly, at the beginning of this period, the spray program was based on Bordeaux mixture for the control of apple scab, together with an arsenical as insecticide. The major insect pests at that time were canker-worms, tent caterpillars, budmoths, codling moth, green fruit-worms and tussock moths. While reports indicate that budmoths and codling moth were then important pests, there is reason to believe that they were not as injurious as in recent years.

Following 1910, lime sulphur partially replaced Bordeaux mixture, mainly in order to reduce the amount of fruit russetting which followed the use of Bordeaux mixture near the time of bloom. About this same period, lead arsenate came into common use and power sprayers were introduced.

Beginning about 1918 the practice of orchard dusting became common and reached its height about 1924. Both sulphur and copper-lime dusts were used along with lead or calcium arsenate. Lime-nicotine sulphate dust was also introduced as a contact insecticide during this period. Kelsall (7) has pointed out that the extensive use of dusts was terminated mainly because of extreme outbreaks of the eye-spotted budmoth, *Spilonota ocellana* (D. & S.), and the appearance of the European red mite, *Meta-tetranychus ulmi* (Koch) (*Paratetranychus pilosus* (Can. & Fanz.)), as a serious orchard pest.

During the next few years modified lime sulphur sprays came into general use to be in turn gradually replaced by elemental sulphurs. Both calcium and lead arsenates, as well as nicotine sulphate, continued to be employed. Dormant oils were used extensively during the latter half of the 1930's for the control of the oystershell scale, *Lepidosaphes ulmi* (L.).

¹ Contribution No. 2458, Division of Entomology, Science Service, Dominion Department of Agriculture, Ottawa, Canada.

² Entomologists, Dominion Entomological Laboratory, Annapolis Royal, N.S.

During this period of development of spray practices, such formerly well-known pests as the cankerworms, fruitworms and tent caterpillars became of minor importance in commercial orchards. Others such as the eye-spotted budmoth and the codling moth increased greatly in importance. Still others, including the gray-banded leaf roller, *Argyrotaenia mariana* (Fern.), and the European red mite which were not mentioned in the earlier literature have now become major pests. There are some references to oystershell scale on apple in the literature previous to 1900; it apparently was of minor importance from about 1900 to 1930, but has since increased until it is now a major pest.

METHODS OF APPROACH TO PEST CONTROL PROBLEMS

The approach to the problem of insect control has been influenced by the traditional method of compartmentalizing fields of investigation. There is a tendency for horticulturists, soil specialists, plant pathologists and entomologists to proceed independently with their own special lines of research without properly integrating the results of one with the other and with the whole problem of apple production. There has also been a tendency for entomologists to believe that the spray method could be made to deal adequately with the whole field of apple insect control and they have thus left other avenues of investigation insufficiently explored. Dr. F. H. Lathrop, remarked at a conference of entomologists of Maine and the Maritime Provinces held at Fredericton on January 23, 1941, that "It is possible that if spraying had never been introduced we would still have found ways of growing good apples."

The pressure on economic entomologists for the prompt elimination of apple pests has encouraged them to take a short-term view of insect control problems. Investigators consequently aimed at the development of spray programs to control those pests of immediate importance, with little or no regard to other organisms which at the time seemed of little consequence. A fungicide, for instance, might be applied to control apple scab, and any control it might exert on other pests was deemed an additional asset, but little or no attention was paid to its influence on the total fauna and microflora of the environment into which it was projected. In addition, replication of experiments in the same orchard for several years was seldom practised, so that there was no long-term measure of the effect of a spray program—the effect not only on pests but also on those insects, mites and other organisms of direct or indirect importance in natural control.

Examined from another viewpoint, the traditional approach may be criticised for not effectively applying ecological concepts and methods to the problems of economic entomology. This situation has continued in spite of the fact that ecologists and some entomologists have, from time to time, emphasized the importance of the ecological aspects of economic entomology. As long ago as 1915, Forbes (6) pointed out that, "It is not because we do not know what we commonly call the *entomology* of the chinch-bug and the Hessian fly and the white-grubs and the cotton-moth that we are so nearly at our wit's end in our efforts to devise means for their control; it is because the knowledge of their entomology merely is not sufficient for the purpose for the purposes of this discussion at any

rate, the subject matter of ecology may be defined as the relation of organisms to their environment, and that this means the *whole* environment, organic and inorganic, and any and *all* organisms, man included the economic entomologist is an ecologist pure and simple, whether he calls himself so or not." Again, Townsend (11) in 1926, expressed the same viewpoint when he wrote, "Environmental investigations furnish the only sure basis for work leading to the speedy discovery of proper measures for the control of insects whether for the suppression of injurious forms or for the extension of beneficial ones. The most perfect control in all cases consists in manipulating certain factors of the environment with reference to the insect in question." Allee (1) in 1927 pointed out the need of studies to determine the factors which cause stability or instability in biotic communities. He says, "A knowledge of such interrelationships within the community is essential for a real understanding of animal life in nature and should precede any attempt to tamper with a community by applying artificial conditions made necessary by modern economic work." Taylor (10) in 1935 wrote: "The interrelationships between the members, plants and animals, of a biotic community are vital, not incidental Disturbance of a single important species of plant or animal is likely to have far-reaching effects on many or all other plants and animals."

Since the preparation of this article was begun there has come to hand a most significant paper by Nicholson (8). This article outlines a theoretical basis for an approach to the problem of insect control which is similar to that which the present authors are attempting to put into practice. While we do not wish at this time to take sides in the current discussions dealing with the factors governing the density of insect populations, which have been indulged in by some writers, the authors of the present paper agree in principle with Nicholson's theoretical approach to the study of the relationship of sprays to insect populations. As Nicholson says, "There is no simple answer to this question, for the addition of a new factor to a complex equilibrium system may cause ultimate effects which are entirely different from the direct effects of the new factor." It is important that these different factors be recognized and their significance appreciated.

It would appear that a valid challenge has been presented by these and other writers and that this challenge has been largely ignored by economic entomologists. It is time that its implications were accepted and acted upon. The present status of our orchard pest control problems makes it necessary to explore the possibilities of a more dynamic method of approach. There is no denying the fact that such an approach presents tremendous difficulties, both because of the complexity of organic and inorganic interrelations which must be explored, and because of the formidable requirements in terms of increased quantity and quality of personnel and material requirements.

OUTLINE OF INVESTIGATIONS IN NOVA SCOTIA

In order to determine the effect of the various spray chemicals on the pest control problem of Nova Scotia orchards, a series of long-term experiments are now underway. Many problems are involved in selecting orchards suitable for studies of this kind. In order to study population

relationships that exist before any spray is applied, and then to follow the succession of changes which occur as spraying is continued from year to year with the same materials on the same block, orchards in a state of neglect are used. To complement such studies, commercial orchards, in which special pest problems exist, are selected. These orchards have been conditioned by a spray program so that the various species are at different population levels from those of unsprayed orchards. As a new spray program is applied to such an orchard for several years any changes in population can be observed. The fact that the course of these changes may be quite different in each of these two types of orchard, necessitates the use of both.

Insofar as is practicable, individual spray chemicals are studied separately. Since observations made over a period of years suggested that the fungicides commonly used in Nova Scotia had a pronounced effect on the prevalence of certain pests, our attention has been largely devoted to a study of their effects because, under Nova Scotia conditions, fungicides must be used to control apple scab.

The methods to be used in recording population changes of many species are by no means fully evolved, and will be modified as conditions require. The essential basis of present methods is the taking of periodical numerical records on as many species as possible. These are taken, for the most part, directly in the field and usually with the aid of binocular microscopes. Experience soon showed that many of the organisms could be grouped, on the basis of numbers and mobility, so that their populations could be determined simultaneously by examination of a unit of a certain size. For example, many species of mites and their eggs, certain insects and insect eggs may be recorded at one time by examination of a specified number of leaves, but this number may not be large enough for more sparsely distributed forms such as budmoth or codling moth eggs or such very mobile forms as mirids, which need to be counted separately or along with another group. Still another grouping includes larvae, such as leaf rollers, budmoths, leaf miners, etc., as well as their larval and pupal parasites. Records of very active insects may be taken by examining a number of trees in each plot for a specified length of time. This method is used, for instance, in measuring the numbers of adult *Aphelinus mytilaspidis* LeB., an important parasite of oystershell scale. Still another and very promising technique is that of dusting a different tree in each plot periodically with a quick-acting dust and collecting the affected arthropods on trays of measured area.

Further details will not be given here as they will be covered in later papers dealing with individual species. An indispensable adjunct to detailed counts is general observation, for, as Allee (1) has pointed out, "An obvious method of supplementing and expanding the data of statistical ecology is by plain, intelligent observation. We need at the present time such field observations on the interrelations of members of insect communities by gifted observers more than we have ever needed them because now they can be of immediate importance as well as of interest. The method is time-consuming but may yield illuminating results without which the data from modern statistical and experimental work cannot be correctly interpreted, if indeed they can be successfull collected."

To supplement the field studies, a number of small trees have been caged and adult codling moths and budmoths placed within to build up large populations of eggs. The cages are then removed and periodical counts made on the condition of the eggs and larvae, and as much as possible of the other fauna of the trees. A certain amount of insectary work has been done in rearing immature forms for identification, but this work should be expanded to gain a more intimate knowledge of the life histories and habits of many species.

BRIEF DESCRIPTION OF EXPERIMENTS

As detailed experimental results will be included in future papers, only a brief description of the various experimental orchards and treatments as well as short notes on the more evident trends in faunal populations will be given here.

Hiltz—South Yarmouth Orchards, Berwick

This is a 10-acre block, about 35 years old, chiefly of Baldwin, Gravenstein, Golden Russet, Wagener and Northern Spy. It is cultivated with a sod strip along the tree rows. As the soil is a light gravelly loam, the orchard suffers somewhat from drought in dry seasons, and the trees are therefore of only moderate size and past their prime bearing condition. It is surrounded on all sides by sprayed orchards.

This orchard was selected because it had the worst infestation in the area generally most heavily infested with codling moth. It was used for experimental purposes for some years previous to the establishment of the present project and its history is well known.

Since 1943 the north half of the block has been treated with copper sprays and the south half with sulphur sprays. Three pre-blossom fungicidal sprays without an insecticide are applied each year, followed by 3 post-blossom sprays containing 3 pounds of lead arsenate per 100 Imperial gallons of the fungicide spray; by 1 straight lead arsenate spray; and finally by 2 applications of cryolite, making a 9-application program.

Among the more significant results observed to date are the following:

(1) In the copper-sprayed portion, the European red mite has practically disappeared. This is evidently due to the establishment of effective populations of predators which include predacious mirids, the predacious mite *Seiulus* sp., and the thrips *Haplothrips faurei* Hd. The clover mite, *Bryobia praetiosa* K. increased to some extent on this plot but was later controlled mostly by the raphignathid mite, *Mediolota novae-scotiae* Nesbitt and probably also by mirids and *Haplothrips faurei*. Very little red or clover mite survived to overwinter in 1944 or 1945.

(2) In the sulphur plot, the European red mite has persisted as an important pest. While the sulphur sprays probably gave some control during the spraying season, a build-up in population took place after spraying was discontinued, so that each year a substantial population of red mite appeared in late August and early September on this plot, which stood out in marked contrast to the copper-treated section. Later in September and October the winter eggs of the mite were heavily fed upon by *Haplothrips*

faurei. There is some evidence that this predator does not thrive under a sulphur spray program and that it was attracted to this part of the orchard by the large numbers of red mite eggs after considerable weathering of the sulphur sprays had taken place. While its origin is not certain it apparently migrated to some extent, at least, from the copper-treated area. The predacious mite *Seiulus* sp. was practically absent from this section of the orchard and was apparently suppressed by the direct effect of the sulphur. The mite, *Mediolota novae-scotiae* which is such an important predator on the clover mite, was also absent. The clover mite is presumably controlled directly by the sulphur since it did not occur in the sulphur plot.

(3) At the time the treatments were started the population of the oystershell scale, *Lepidosaphes ulmi* (L.) was very low in this orchard. During 1943 and 1944 there was very little change, but in 1945 a marked increase occurred in the sulphur plot. Records taken from 37 Baldwin trees in the copper plot showed an average of 2.3 scales per 100 inches of new growth, whereas a similar record from 38 Baldwin trees in the sulphur plot gave an average of 102.6 scales. The probable reason for this difference will be discussed in connection with the work in the Palmer orchard.

Palmer Orchard, Berwick

This is a block of nearly 5 acres of trees about 30 years old, predominantly Stark, Cox Orange Pippin, Northern Spy and Ben Davis. This area forms about $\frac{1}{3}$ of a larger orchard, the balance of which is cared for entirely by the owner. The experimental block is surrounded by sprayed orchards on three sides and by a small area of pine woods on the fourth. The soil is a deep, fairly light sandy loam and is not affected by drought to any marked extent. The trees have been well cared for and are growing vigorously. The soil is cultivated in the spring by discing.

This orchard was selected because of a fairly heavy infestation of oystershell scale and treatments were started in 1943. Four fungicides have been included in the tests, namely, lime sulphur, flotation sulphur, copper (Bordeaux mixture and fixed copper being used on the same plot) and the organic fungicide, ferric dimethyl dithiocarbamate (Fermate). Lead arsenate has been used as an insecticide in all sprays following the bloom. Throughout the course of the tests it has become evident that both forms of sulphur almost entirely prevent the development of the mite *Hemisarcoptes malus* (Shimer), which is an important predator of the oystershell scale and which if not suppressed will ordinarily keep this pest under control. This predator develops freely under the Fermate treatments and is evidently only slightly, if at all, suppressed by copper treatments. Similar effects have been noted on the development of the parasite *Aphelinus mytilaspidis* which attacks the oystershell scale. This parasite develops freely on both the copper and Fermate plots throughout the season but is found on the sulphur-treated trees only after this material has undergone weathering for several weeks. Flanders (4 and 5) observed in California a similar effect on the parasite, *Metaphycus helvolus* (Compere), which attacks the black scale, *Saissetia oleae* (Bern.). Cox (3) also noted that dormant lime sulphur sprays were lethal to the parasites of the San Jose and terrapin scales.

After 3 years' treatment, the oystershell scale has practically disappeared from the Fermate-treated trees, and has been greatly reduced on those treated for only 2 years. Table 1 gives the results obtained with the various treatments used.

TABLE 1.—OYSTERSHELL SCALE ON SPRAYED TREES

Changes in oystershell scale population per 100 in. of new growth	% of 1945 scales* dead before oviposition
On Fermate after 3 years treatment from 759 to 1	99.7
On Fermate after 2 years treatment from 284 to 67	93.8
On lime-sulphur after 2 years treatment from 66 to 91	72.2
On copper after 2 years treatment from 382 to 39	79.6
On flotation sulphur after 2 years treatment from 156 to 413	25.4

* These figures include only those scales which became established on the new growth.

Results from treatment for 2 years with copper sprays are very similar in that the scale problem is well on its way toward elimination. Lime sulphur plots, after 2 years' treatment, show no marked change in scale population, probably because this chemical itself directly controls oystershell scale to a marked extent when used throughout the spraying season. Nevertheless, a moderate population of healthy scales still persists. On the flotation sulphur plots there has been a definite increase in the scale population where the treatments have been continued for 2 years; there are practically no predacious mites and only a small number of *Aphelinus*. It is of interest to note that this orchard is divided into single and double row plots and that the parasite and the predator have remained confined to the Fermate and copper-treated plots throughout their several generations. However, the last generation of adult *Aphelinus* may migrate into the sulphur-treated plots in September, with the result that overwintering larvae of this parasite may be almost as abundant on sulphur-treated trees as on those treated with copper or Fermate.

Extensive records have been taken on the fluctuations of the European red mite populations in this orchard but the plots are apparently too small to give clear results. The high degree of mobility of many of the important predators of this mite considerably modifies the differential effects of the various spray chemicals on their development.

Drew Orchard, Berwick

This is a 2-acre block surrounded on three sides by sprayed orchards. The trees are about 30 years of age; on the whole, they have been poorly cared for and are small for their age. The soil is a gravelly loam and the trees are affected by drought in dry seasons. The orchard is situated about $\frac{1}{4}$ mile from the Hiltz-South Yarmouth block and is on a similar type of soil. When the experiments were started in 1944 the trees had been unsprayed for about 10 years.

Fungicides alone have been put on three different groups of trees and one group has been left without treatment. The fungicides used were flotation sulphur, copper and Fermate. The following are some points of interest noted in this orchard:

(1) Unsprayed trees were characterized by a large number of arthropod forms, this condition being most striking in regard to Acarina. Among those found on the leaves of unsprayed trees are phytophagous species such as the European red mite, the clover mite, the red spider, *Tetranychus bimaculatus* Harvey and Eriophyids. Other forms found on leaves include the predacious mites, *Seiulus* sp., *Anystis* sp., *Mediolota novae-scotiae*, and two species of Bdellidae. There are also a number of others of no apparent direct importance such as *Czenspinskia lordi* Nesbitt, *Tarsonemus* sp., and *Tydeus robustus* Bks. Many other species not listed above are found on the trunk, limbs and twigs. These appear for the most part to be scavengers but one, *Hemisarcoptes malus*, is a most important predator on oystershell scale.

(2) The copper-sprayed trees did not differ greatly from the unsprayed trees. There was no marked build-up of European red mite and clover mite, in direct contrast to what ordinarily happens when the change is first made from sulphur to copper sprays. Most of the species of mites found on unsprayed trees were able to survive copper spray treatment.

(3) On the Fermate plot a slight build-up of clover mite and an appreciable increase in European red mite took place. Both decreased later in the season. There were indications of some interference with natural conditions but these were not so marked as with sulphur.

(4) The sulphur-sprayed plot showed a marked reduction in the general mite populations and a number of species, some known to be beneficial, were practically eliminated. European red mite was kept to a fairly low level during the spraying season but increased markedly after spraying was discontinued. *Haplothrips faurei* appeared in considerable numbers in the fall and destroyed many of the eggs.

(5) There was less parasitism of the eggs of the eye-spotted budmoth, *Spilonota ocellana*, by *Trichogramma* sp. on the sulphur plot than in the other treatments or the unsprayed plot. This was consistent during the 2 years that the experiment has been underway. Schread and Garman (9) in Connecticut have recorded similar results with *Trichogramma* on the oriental fruit moth.

Wolfe Orchard, Waterville

This orchard had been badly neglected for many years and at the time the experiment was started in 1944 birch saplings were growing higher than the 30 year old apple trees. It consists of a block of several acres in the vicinity of large areas of commercially sprayed orchards. The soil is a gravelly loam on which the trees are not seriously affected by drought. The soil has been uncultivated but during the 2 years the experiment has been underway the trees have been well fertilized.

The fungicide Fermate has been used alone on a block of about 1 acre in this orchard and the balance has been left unsprayed as a check plot. The following are some of the points of interest noted so far:

(1) The European red mite has not increased to any extent on the Fermate plot during the 2 years.

(2) There was a slight increase in the clover mite population, possibly due to the fact that the afore-mentioned raphignathid mite *Mediolota novae-scotiae* was inhibited by Fermate. The records suggest that most of the other mites were not seriously affected. *Haplothrips faurei* was numerous in August, 1945, on both the unsprayed and sprayed plots.

Aldershot Orchards, Kentville

These are four blocks of moderately young orchard belonging to the Aldershot military camp, each fairly well isolated from any other orchard in the vicinity. These orchards, neglected for 5 years previous to 1945, were made the basis for a long-term experiment to measure the population changes brought about by the continued use of some common spray materials over a period of years. During 1944, some preliminary population studies were made and all through the growing season of 1945 records were kept of the insect and mite populations. Some changes in population status have occurred but a discussion of these will be left for a later paper after more information has been gathered.

On one of these blocks, consisting of 8 acres mostly of Ben Davis but with a few Wealthy, a Fermate program is being used, with the addition of lead arsenate on half of the block. A second block of 3 acres of Stark and Ben Davis is being treated with flotation sulphur, without an insecticide. Another $1\frac{1}{2}$ acre block of Ben Davis and King of Tompkins is being treated with copper sprays without an insecticide. The fourth block consists of 3 acres mostly of Ben Davis and here the ground and the trees were treated with sodium dinitro-o-cresylate (Elgetol) in the dormant period. This was followed by a Fermate program without an insecticide. Owing to delivery difficulties, no sprays were applied to the Fermate areas until the trees were in the pink stage, but the application of Elgetol reduced the early infection of apple scab to such an extent that the trees nevertheless retained a dense foliage throughout the season. This was in direct contrast to the other Fermate block which was seriously infected although it was treated the same except for the lack of the Elgetol spray.

Experimental Station Orchard, Kentville

This is a variety test orchard of 200 trees about 25 years old, at the Dominion Experimental Station. There are a number of varieties including many of the various strains of Delicious. This orchard is on a deep, fertile loam soil in a good location and except on one side is surrounded by other sprayed orchards which belong to the Experimental Station.

The sprays have been applied by the staff of the Experimental Station while the faunal records were taken by the staff of this laboratory. The spray program follows the regular Nova Scotia schedule of 3 Bordeaux and 3 sulphur applications, but in place of lead arsenate, DDT was added to the pink and the 2 cover sprays. No insecticide was used in the other applications. The interesting feature in connection with the population studies in this orchard was the tremendous build-up of European red mite and the almost complete absence of the predators of this mite. The effect on the mite and its predators was similar to that of sulphur but the violence of the action was decidedly greater and predators did not appear so promptly after spraying was discontinued. In fact the small amount of predation that had occurred up to the end of October was due only to an unidentified species of anthocorid, aphid lions and *Seiulus* mites.

DISCUSSION

This paper is merely a progress report on the methods being employed and on the more outstanding results. The work to date has been largely of an exploratory nature, and it is not suggested that the investigation is all-inclusive or that the methods should not be modified, and, in fact, it would appear that considerable modification will be necessary. The greatest weakness in present procedure is that small plots have only a limited value. Valuable results have been obtained from these small plots on pests with low powers of mobility, such as oystershell scale and mites, but when winged insects are considered, the area under observation should be much more extensive. How large the test area should be will vary with each insect, but in some cases would probably need to be hundreds of acres in extent. Not only does the mobility of the pest need to be taken into account, but also the mobility of the parasites and predators. This has been well illustrated in the studies on oystershell scale; where there was an opportunity for the parasite *Aphelinus* to develop during the summer on copper or Fermate-sprayed trees, adults of the last generation very promptly migrated to nearby sulphur-sprayed trees in September. This was in direct contrast to the predacious mite, *Hemisarcoptes malus*, which is very sluggish in its movements, and remained almost entirely absent from sulphur sprayed trees even though it might be very numerous on an adjoining tree.

There is no minimizing the difficulties involved in conducting an investigation of the scope outlined in the foregoing. In order to make it a success it will have to be approached in the spirit set forth by Ball (2) when he said: "We need more of the Spirit of Research—the inquiring mind—the spirit that subjects all statements to analysis before acceptance—the spirit that holds all truths as simply the best deductions from the evidence available but subject to modification at any time on the basis of new evidence. Such a spirit welcomes constructive criticisms and invites co-operation. Such a spirit grows and expands with the increasing knowledge and is ever young and up-to-date."

SUMMARY OF RESULTS TO DATE

In the short time that this project has been underway, distinct faunal differences have shown up in orchards treated with sulphur, copper and Fermate sprays. It may be safely stated that, in general, there is a much smaller number of species of arthropods on sulphur-treated areas but not necessarily a smaller number of individuals. This is particularly true of the mite fauna, most species being practically eliminated from sulphur-sprayed trees. On the other hand, the European red mite, as a result of the repression of natural control agents, may become very numerous after the spraying season. On blocks which have had a copper spray program there is much less interference with the arthropod fauna so a much larger number of species occur, but with fewer individuals than on sulphur-sprayed trees. On Fermate-treated trees there is probably more repression of the fauna

than where copper is used but not nearly as much as on the sulphur-treated areas. As stated above, sulphur represses a large number of species which include beneficial forms. Because of this, a change to a less harmful material such as copper or Fermate sprays may at first result in an increase of some species until their natural control agents become established. Experiments to date have shown that the oystershell scale outbreak which developed in Nova Scotia since 1930 was due to interference with the natural control of the scale by the use of mild sulphur sprays which repress the parasites and predators but have little effect on the scale itself. When sulphurs, and other spray chemicals which have a depressing effect on the parasites and predators of the scale, are replaced by copper or Fermate the scale population is soon decimated.

ACKNOWLEDGMENTS

The authors wish to acknowledge the very generous assistance received from a number of fruit growers who have co-operated in these studies by making their orchards available to us for experimental work.

Special mention should be made of the assistance provided by the Nova Scotia Fruit Growers' Association, the Dominion Experimental Station, Kentville, N.S., and the Camp Commandant, Infantry Training Centre, Aldershot, N.S. We also record our indebtedness to Mr. W. A. Ross, Chief, Fruit Insect Investigations, who has given timely advice and encouragement while these studies were being initiated and who has made numerous suggestions regarding the preparation of this paper.

REFERENCES

1. ALLEE, W. C. Insect ecology. Ann. Ent. Soc. Amer. 20 (4) : 439-444. 1927.
2. BALL, E. D. Symposium:—Needed lines of investigations in American entomology. Introduction. Ann. Ent. Soc. Am. 20 (4) : 419-422. 1927.
3. COX, JAMES A. Effect of dormant sprays on parasites of the San Jose and terrapin scales. Jour. Econ. Ent. 35 (5) : 698-701. 1942.
4. FLANDERS, STANLEY E. *Metaphycus helvolus*, an encyrtid parasite of the black scale. Jour. Econ. Ent. 35 (5) : 690-698. 1942.
5. FLANDERS, S. E. The susceptibility of parasitic Hymenoptera to sulphur. Jour. Econ. Ent. 36 (3) : 469. 1943.
6. FORBES, STEPHEN, A. The ecological foundations of applied entomology. Ann. Ent. Soc. Am. 8 (1) : 1-19. 1915.
7. KELSALL, ARTHUR. Thirty years experience with orchard sprays in Nova Scotia. Sci. Agr. 14 (7) : 405-410. 1939.
8. NICHOLSON, A. J. Indirect effects of spray practice on pest populations. Verhantl. 7 Int. Kongr. Ent. Berlin 1938.4 : 3022-3028. Weimar, 1939. (Review in Rev. Appl. Ent. Ser. A. 33 (8) : 254).
9. SCHREAD, J. C. and P. GARMAN. Studies on the parasites of the oriental fruit moth. I. *Trichogramma*. Conn. Agr. Expt. Sta. Bull. 353. 1933.
10. TAYLOR, WALTER P. Significance of the biotic community in ecological studies. Quart. Rev. Biol. 10 : 291-307. 1935.
11. TOWNSEND, CHARLES H. T. Methods of environment work for indicating insect control measures. Ecology 7 : 326-337. 1926.

AGRONOMIC TERMINOLOGY¹

The Committee on Agronomic Terminology of the Western Canadian Society of Agronomy presented to the annual meeting of that organization, a brief report on some agronomic terms which had been submitted to it for consideration. Some of these terms proved to be words which may or may not be used synonymously; there were others which have been coined during recent years and have been used more or less interchangeably with older, less embracing word forms. This committee has endeavoured to define these words in order to reduce to one the number of terms which could be applied to a given case or circumstance.

A number of words, with their accompanying definitions, were proposed to the general meeting. The words and definitions were discussed, amendments made where necessary in the definitions, then a vote taken as to whether or not they were acceptable to the members present. These words and their accompanying agronomic definitions, are being published in order to bring them to the attention of other agronomists. Anyone objecting to any of these terms or their definitions, in whole or in part, or wishing to submit other terms for consideration is requested to communicate with any member of the committee.

Association

Is essentially synonymous with *correlation* but is applied when the data are obtained in *descriptive* categories or in *numerical* categories which are of unequal magnitude.

Companion Crop

Nurse crop is commonly used in Canada to denote a grain crop in which forage crops are sown, and it is believed by many to denote a beneficial plant relationship. While this may be correct in specific instances, it has been found that, at least under prairie farming conditions, there is often a serious competitive effect which results in poor stands of the forage crop being obtained. The Committee on Crop Terminology of the American Society of Agronomy² has proposed the term *companion crop* as more accurately describing the existant relationship.

Correlation

Study of the simultaneous variation of two or more variates when the categories are numerical and of *equal magnitude*.

Forage

Used as a noun it is coming into general use as descriptive of all edible plants either suitable for hay or for the maintenance of live stock under range or pasture conditions. It embraces plants which fall in the category of *herbage*. The latter is a collective term embracing only those seed plants without woody stems which die back to the ground after flowering.

¹Report presented to the annual meeting of the Western Canadian Society of Agronomy, held in Winnipeg, Manitoba, June 19, 1946.

²Crop Terminology. Jour. Amer. Soc. Agron. 35 : 1053-1055. 1943.

Herbicide

Descriptive of numerous sprays and dusts recommended for application to and eradication of higher plants. The degree of selectivity¹ depends upon the concentrations applied and the characteristics of the plants themselves, e.g., depth of root penetration, wettability of the leaves, position of the growing point. The variety of terms appearing in popular literature, e.g., selective herbicide, hormone spray, weed killer, etc. are therefore but variations of the original term *herbicide*.

Plot

Any small unit of land used for experimental purposes. *Plat* is sometimes used as the equivalent in U.S. literature. It is of Old English origin and its use offers no advantage.

Replication

This term has been the cause of much argument. In the strictest grammatical sense it is incorrectly used. Nevertheless it is believed that it would be unwise to attempt the introduction of any other word to replace *replication*, for it is so much a part of our experimental language. Therefore the generally accepted definition is endorsed in this report. Replication may be used to denote the original set, or one or more repetitions of that original set, of treatments, varieties, etc.; thus we can speak of one, two, or more *replications*.

Rhizome

This is the accepted botanic term for horizontal under-ground stems often erroneously spoken of as creeping or running roots. It has been adequately defined in botanic literature.

Slender Wheatgrass

Agropyron trachycaulum (Link) Malte var. *typicum* Fern. formerly *Agropyron pauciflorum*. A member of the genus which embraces the group commonly called the wheatgrasses. The use of *western ryegrass* is incorrect and therefore its use must be discouraged. Furthermore, the latter is suggestive of other genera as *Elymus* (Wild-rye) or *Lolium* (Ryegrass).

Tillering or Stooling

Synonymous. *Stooling* was first applied in horticulture and forestry to denote growth from stumps and basal parts of the plant. *Tillering* appeared in the literature later and was applied to secondary shoots in cereal crop plants. The latter seems to have been preferred by Percival.²

¹ Crafts, A. S. Selectivity of herbicides. *Plant Physiol.* 21 : 345-361. 1946.

² Percival, John. *The Wheat Plant*. Duckworth and Co., London, 1921.

J. G. DARROCH (*Chairman*)
R. W. PEAKE
W. H. JOHNSTON